THE

Malayan Agricultural Journal.

Vol. XII. Sept. & Oct., 1924. Nos. 9 & 10.

FIELD EXPERIMENTS RELATING TO BROWN BAST DISEASE OF *HEVEA BRASILIENSIS*.

By A. Sharples and J. Lambourne.

Introduction.

THE Brown Bast disease of the Para Rubber tree, (*Hevea brasiliensis*) has aroused great interest, even in temperate climates. Doubtless much of the interest was due to the great increase in number of Brown Bast cases observed about 1917, and the obscure nature of the affection has maintained scientific interest since. Locally, numberless articles in more or less popular form have appeared in various periodicals which cannot be dealt with in this paper ; a good bibliography can be found in (6) and (11).

Keuchenius (6) points out that the "burred" stems characteristic of a long-standing Brown Bast attack have been known since the earliest plantings in the Middle East and were known in the Amazon region in 1887. The earlier stages of Brown Bast, i.e. water-logged bark and stoppage of latex flow, were observed many times in Malaya during 1914, but at this time, following on Rutgers observations and statements (12) respecting the action of *Phytophthora Faberi* (*Maub*) on the stems of rubber trees, the symptoms were regarded as a possible reaction against this organism, despite the fact that this fungus was never isolated from the diseased tissues by any of the investigators in Malaya.

Pratt (8) in 1917, who had had considerable experience in Malaya before going to Sumatra, was the first observer to record and class the symptoms now described for Brown Bast, as distinct from the symptoms described by Rutgers (12) for the action of *Phytophthora Faberi*. He clearly stated the differences and as a result, concentrated work on Brown Bast became possible.

The senior author took up this work in 1920. The position at that time has been reviewed (14) but a short re-statement may be of interest. The recognition of Brown Bast as distinct from other bark affections and its apparent wide-spread distribution, led to the formation of a Brown Bast Investigation Committee (B.B.I.C.) in Malaya.

In Java and Sumatra, various investigators were at work, notably Rands, Keuchenius and Harmsen. The investigations of the B.B.I.C. practically parellelled the work of Rands in Java and the results obtained were almost identical. These results were entirely in favour of the view that Brown Bast must be regarded as a "physiological disease" the cause being non-organic. Keuchenius has steadily supported the "bacterial" origin of Brown Bast and in his latest published work (6) still maintains this view.

Symptoms.

The symptoms have been described repeatedly. The only certain macroscopic symtoms are the cessation or falling-off in latex yield, with the cortical tissues becoming somewhat succulent, i.e., water-logged, and taking on a definite discoloration, ranging from blackish-grey or greyish-brown to a sepia colour. Our own experience shows that the earliest and most usual Brown Bast indication is a slight discoloration of the bark in the tapping cut which appears in small brownish patches or spots. In a number of cases there is a preliminary substantial increase in latex flow, but in an equal number the cut commences to dry and the latex coagulates on the cut. If a tree has been a normal yielder in full foliage and not otherwise diseased, either of these signs is a practically sure indication that a Brown Bast attack is imminent. During the wintering months in Malaya, the drying of the cut alone cannot be accepted as an indication of Brown Bast, as during this period a number of trees become partly or altogether dry.

Keuchenius (6) extends this description as follows:—"und besitz das vermogen zur Metastase." He also points out that various authors, Harmsen (5), Rands (10) and Bobillioff (1) believe that the earliest macroscopic symtoms are antedated by microscopic changes in the affected tissues, and that trees liable to an early Brown Bast attack can be detected by a microscopic examination. He rightly remarks that Brown Bast cannot be diagnosed with certainty unless the macroscopic symtoms are well-marked.

Scope of Present Work.

An overwhelming mass of evidence (14) has accumulated from various sources to show that Brown Bast is nontransmissible. All inoculations have proved unsuccessful up-to-date. Accepting the position as shown by the unsuccessful inoculations, the only line of investigation left open was to try to test the various factors which might influence the incidence of the affection.

Tapping experiments, set up by the B.B.I.C. were in hand when the authors took up this work. These early experiments were designed to test the relative effects of estate routine tapping against the effects of heavy tapping, with varying intervals between successive tappings. The method was based on that used by Rands in Java (11) but a less severe system was finally adopted. The results of this initial series of experiments were unexpected and required confirmation.

Rands was the first investigator experimentally to show that excessive tapping effects the percentage development of Brown Bast to a considerable degree. After preliminary trials had been run in Malaya by the B.B.I.C. Belgrave (then Acting Mycologist) suggested that a single cut per day over the whole circumference would be sufficient to obtain comparative data. It was advisable to approximate as closely as possible to routine conditions, so the least severe tapping system possible under the experimental conditions was desirable.

The initial experiments set up by the B.B.I.C. consisted of nine plots, testing ¼ Spiral cuts, ½ Spiral cuts, against Full Spiral cuts. Each system was triplicated, *i.e.* Every Day (E.D.) Alternate Day (A.D.), and Every Third Day (E.T.D.). The experiments were carried out on the Government Plantation, Teluk Anson. The trees were well-grown, 12 years old, and the estate had been run on the best lines since 1912 when the Department of Agriculture took control. The following tables give the results obtained over a period of nine months, from April, 1919 to December, 1919.

TABLE No. 1.

Tapping System.		Month.	No. of trees in plot.	No. of dry trees when experiment started.	No. of trees tapped.	Total Rubber.	Average yield per tree.
¼ Cut	(Daily -	April 1919	554	39	515	67.13	.13
	(Alternate Day -		554	24	530	24.3	.05
	(Every Third Day		554	52	502	14.32	.03
½ Spiral	(D. -	„	391	50	341	91.51	.30
	(A. D. -		390	59	331	33.6	.10
	(E. T. D. -		390	40	350	17.37	.05
Full Spiral	(D. -	„	613	77	536	231.3	.43
	(A. D. -		613	96	517	121.65	.23
	(E. T. D. -		613	75	538	65.00	.10
¼ Cut	(D. -	May	554	39	515	102.6	.21
	(A. D. -		554	24	530	54.2	.10
	(E. T. D. -		554	52	502	37.11	.07
½ Spiral	(D. -	„	391	50	341	126.10	.37
	(A. D. -		390	59	331	59.1	.18
	(E. T. D. -		390	40	350	36.7	.10
Full Spiral	(D. -	„	613	77	536	346.11	.64
	(A. D. -		613	96	517	184.95	.35
	(E. T. D. -		613	75	538	173.12	.32

TABLE No. 1—(*contd.*)

Tapping System.	Month.	No. of trees in plot.	No. of dry trees when experiment started.	No. of trees tapped.	Total Rubber.	Average yield per tree.
¼ Cut (Daily)	June 1919	554	39	515	117.22	.23
¼ Cut (Alternate Day)	June 1919	554	24	530	69.60	.13
¼ Cut (Every Third Day)	June 1919	554	52	502	43.12	.09
½ Spiral (D.)	June 1919	391	50	341	135.11	.40
½ Spiral (A. D.)	„	390	59	331	57 5	.17
½ Spiral (E. T. D.)	June 1919	390	40	350	41.33	.12
Full Spiral (D.)	June 1919	613	77	536	355.26	.66
Full Spiral (A. D.)	„	613	96	517	234.24	.45
Full Spiral (E. T. D.)	June 1919	613	75	538	166.2	.31
¼ Cut (D.)	July	554	39	515	119.25	.23
¼ Cut (A. D.)	July	554	24	530	63.95	.12
¼ Cut (E. T. D.)	July	554	52	502	42.1	.08
½ Spiral (D.)	July	391	50	341	137.54	.40
½ Spiral (A. D.)	„	390	59	331	56.2	.17
½ Spiral (E. T. D.)	July	390	40	350	41.7	.12
Full Spiral (D.)	July	613	77	536	415.11	.77
Full Spiral (A. D.)	„	613	96	517	240.20	.46
Full Spiral (E. T. D.)	July	613	75	538	171.8	.32

Tapping System.	Month.	No. of trees in plot.	No. of dry trees when experiment started.	No. of tappable trees.	Total Rubber.	Average yield per tree.	No. of dry trees (Brown Bast).
¼ Cut (Daily)	Aug. 1919	554	39	515	122.7	.24	...
¼ Cut (Alternate Day)	Aug. 1919	554	24	530	73.65	.14	...
¼ Cut (Every Third Day)	Aug. 1919	554	52	502	54.8	.10	...
½ Spiral (D.)	Aug. 1919	391	50	341	149.1	.44	...
½ Spiral (A. D.)	„	390	59	331	68.54	.20	...
½ Spiral (E. T. D.)	Aug. 1919	390	40	350	50.9	.14	...
Full Spiral (D.)	Aug. 1919	613	77	536	369.6	.70	...
Full Spiral (A. D.)	„	613	96	517	317.14	.61	...
Full Spiral (E. T. D.)	Aug. 1919	613	75	538	255.2	.50	...

TABLE No. 1—(*contd.*)

Tapping System.	Month.	No. of trees in plot.	No. of dry trees when experiment started.	No. of tappable trees.	Total Rubber.	Average yield per tree.	No. of dry trees (Brown Bast.)
(Daily -)	Sept	554	39	512	86.9	.17	3
¼ Cut (Alternate Day -)	1919	554	24	528	50.	.09	2
(Every Third Day)		554	52	501	41.27	.08	1
(D. -)		391	50	339	83.28	.25	2
½ Spiral (A. D. -)	,,	390	59	329	63.	.19	2
(E. T. D. -)		390	40	350	34.	.09	...
(D. -)		613	77	491	218.27	.45	45
Full (A. D. -)	,,	613	96	505	226.60	.45	12
Spiral (E. T. D. -)		613	75	533	154.21	.30	5
(D. -)		554	39	512	89.44	.17	3
¼ Cut (A. D. -)	Oct.	554	24	528	56.24	.10	2
(E. T. D. -)		554	52	501	55.1	.10	1
(D. -)		391	50	339	84.3	.28	2
½ Spiral (A. D. -)	,,	390	59	329	51.9	.16	2
(E. T. D. -)		390	40	350	54.27	.15	...
(D. -)		613	77	491	289.4	.60	45
Full (A. D. -)	,,	613	96	505	283.2	.56	12
Spiral (E. T. D. -)		613	75	533	307.6	.58	5
(D. -)		554	39	512	89.6	.17	3
¼ Cut (A. D. -)	Nov.	554	24	528	57.56	.10	2
(E. T. D. -)		554	52	501	34.33	.07	1
(D. -)		391	50	339	110.3	.33	2
½ Spiral (A. D. -)	,,	390	59	329	65.75	.20	2
(E. T. D. -)		390	40	350	47.27	.13	...
(D. -)		613	77	491	311.6	.63	45
Full (A. D. -)	,,	613	96	505	269.8	.53	12
Spiral (E. T. D. -)		613	75	533	268.5	.50	5
(D. -)		554	39	510	107.95	.21	5
¼ Cut (A. D. -)	Dec.	554	24	528	67.44	.14	2
(E. T. D. -)		554	52	500	43.72	.085	2
(D. -)		391	50	333	102.7	.30	8
½ Spiral (A. D. -)	,,	390	59	328	67.55	.20	3
(E. T. D. -)		390	40	349	60.13	.17	1
(D. -)		613	77	434	307.6	.70	102
Full (A. D. -)	,,	613	96	483	303.	.60	34
Spiral (E. T. D. -)		613	76	513	271.8	.53	24

The following points are noteworthy:—

(1) The blocks heavily tapped on a Full Spiral, show a high percentage development of Brown Bast.

(2) That Alternate Day tapping compares very favourably with Daily tapping as regards percentage Brown Bast development when a heavy tapping system, (or alternatively when a large quantity of latex is being withdrawn from the tree) is in operation. No certain conclusions can be drawn as to the relative merits of Alternate Day and Daily tapping with reference to Brown Bast, using systems common on plantations, i.e. one-half or one-third cuts.

(3) The apparent sudden jump in number of Brown Bast cases during certain months was noted. The Full Spiral Daily tapping plot showed no Brown Bast cases from April to September; in this month 45 trees with Brown Bast were found. No further cases were noted until December when the total was increased to 102.

(4) Further results of interest are disclosed when the monthly yields are totalled:—

Month.	Daily ¼ cut.	Alt. Daily ¼ cut.	E.T. Day ¼ cut.
	lbs.	lbs.	lbs.
April ...	67.13	24.30	14.32
May ...	102.60	54.80	37.11
June ...	117.22	69.60	43.12
July ...	119.25	63.95	42.10
August ...	122.70	73.65	54.8
September ...	86.90	50.00	41.27
October ...	89 44	56.24	55.10
November ...	89.60	57.56	34.33
December ...	107.95	67.44	43.70
Totals ...	902.79	517.54	365.85

Month.	Daily ½ Spiral.	Alt. Daily ½ Spiral.	E.T. Day ½ Spiral.
	lbs.	lbs.	lbs.
April ...	91.51	33.60	17.37
May ...	126.60	59.10	36.70
June ...	135.11	57.50	41.33
July ...	137.54	56.20	41.70
August ...	149.10	68.54	50.90
September ...	83.28	63.00	34.00
October ...	84.30	51.90	54.27
November ...	110.30	65.75	47.27
December ...	102.70	67.55	60.13
Totals ...	1019.94	523.14	383.67

Month.	Daily F. Spiral. lbs.	Alt. Daily F. Spiral. lbs.	E.T. Day F. Spiral. lbs.
April ...	231.30	121.65	65.00
May ...	346.11	184.95	173.12
June ...	355.26	234.24	166.21
July ...	415.11	240.20	171.28
August ...	369.60	317.14	255.20
September ...	218.27	226.60	154.21
October ...	289.24	383.20	307,60
November ...	311.60	269.80	268.50
December ...	265.60	245.00	271.80
Totals ...	2802.25	2122.78	1832.91

If the total yield on the daily cut is taken as standard and the Alternate Daily and every Third Day totals are multiplied by two and three respectively, the latter totals should fall somewhere near the total for the daily tapping if equal quantities of latex are extracted when equal quantities of bark are removed during tapping systems. The expected results are obtained under the light tapping systems:—

	Daily	¼	cut	Total ...	902.79
Alternate	,,	,,	,,	,, × 2 ...	1035.08
E.T. Day	,,	,,	,,	,, × 3 ...	1097.55

	Daily	½	Spiral	Total ...	1019.94
Alternate	,,	,,	,,	,, × 2 ...	1046.28
E.T. Day	,,	,,	,,	,, × 3 ...	1151.01

The blocks tapped on the ½ Spiral system contained 350 trees as against 500 in the remaining blocks.

The Full Spiral blocks compared in the above manner give:—

	Daily	Full	Spiral	Total ...	2802.25
Alternate	,,	,,	,,	,, × 2 ...	4245.56
E.T. Day	,,	,,	,,	,, × 3 ...	5498.76

The results from the Full Spiral blocks are very much out of line compared with those obtained under lighter or routine tapping. Such results give colour to the view that information obtained under present day conditions may not prove of much value when trees of higher yielding capacities have to be considered. It is practically certain that if such trees are established by vegetative propagation there will be a whole series of new phenomena to be investigated, and from the disease aspect, much danger may be apprehended. From the data obtained in these experiments it seems possible that above a certain yield figure the percentage amount of Brown Bast will be a factor to be considered in the estimation of yields from a particular area, more especially if the land is widely planted with a few high yielding trees per acre. Accepting Brown Bast as a possible limiting factor in the

question of yields, and evidence can be advanced in support of this view, the figures obtained indicate the possibility of restricted yields, according to the type of soil and general growth conditions prevailing, in short, that environmental factors are of primary importance in rubber cultivation. This view is strongly supported by the extremely local chracter of good yielding patches in the great majority of present day stands.

This aspect of the Brown Bast problem is of some practical importance at the present juncture in view of the interest shown in the question of increasing yields per acre by seed selection and vegetative propagation.

PART II.

Tapping Experiments.

The previous experiments showed that the Full Spiral cut, once daily, gave a sufficient number of cases of Brown Bast in a short period, so enabling comparative experiments to be set up. Rands system of tapping, i.e. two superimposed cuts on 1/3 of the circumference, tapped six times per day, was much too drastic to gain a line approximating to routine field operations, for when tapping six times per day in Malaya, no latex is obtained from the last two or three tappings. Under such conditions, the influence of wounding owing to repeated tappings would be of too large significance to enable just conclusions to be arrival at. Many authors have pointed out that typical Brown Bast often originates at badly wounded places, far from the tapping cut. Keuchenius (6) draws special attention to the places where large branches have been broken by the wind and where the tree has been injured about the base as a result of wild pigs eating the bark. This author attaches some importance to these observations in his final conclusions and emphasises them in his consideration of what he terms the "Metastase" of the disease. He states that the features included under the term "Metastase" cannot well be accounted for by a "physiological theory." Therefore it is necessary to attempt to assign to the influence of wounding its own relative importance. Heavy yielding, i.e. too rapid withdrawal of latex, goes hand-in-hand with increased wounding in the tapping operation and in practice, it is difficult to separate these two important factors with regard to the initiation of Brown Bast.

Keuchenius (6) stresses the importance of taking care in the diagnosis of Brown Bast and the writers are in entire agreement. Various authors have held that the early stages of the affection can be spotted by submitting microscopic sections to the "Phloroglucin" test. Keuchenius states that this test is most unsatisfactory, a view supported by our own experience. The only reliable test is the well-marked appearance of the macroscopic symptoms in the field. In order to check our Brown Bast determinations as judged from the mecroscopic symptoms, a series of control trees was set up, and are shown in the tables following. These control trees were healthy trees put out of tapping at the same time that a neighbouring tree was suspected of Brown Bast; the suspected trees were

then tapped until a large area of bark was affected. The final test was the development of "Burrs" on the suspected trees. In all cases, "Burrs" developed on the trees marked for Brown Bast while the controls remained normal.

Previous experiments had indicated that three months preliminary heavy tapping was necessary before valid comparisons could be made as to the behaviour of any plot with regard to the incidence of Brown Bast. The experiments following, may be considered as approximating as closely as possible to routine field operations, but it must be borne in mind that generalisations based on routine tapping systems do not necessarily hold good for a more drastic system, so care is necessary in the final deductions.

The experiments were commenced on 1st August 1920, and 410 trees, were selected and divided into two plots with 207 and 203 trees respectively. The trees in Plot 3 were selected from the trees that had been tapped in the previous experiment on the Full Spiral system once every three days, those in Plot 4 from those tapped on a ½ Spiral once every day. These trees had been rested from Dec. 1919 to Aug. 1920 so had had a good opportunity for recovery from previous tapping operations. The tapping was started in virgin bark above the 36" mark and all the trees were put under a Full Spiral cut, once daily, for three months. This preliminary tapping showed a high number of Brown Bast trees in a portion of Plot 3, eight being counted in a confined area. The total number of Brown Bast trees after three months was 18 in Plot 3 and 7 in Plot 4. This difference might be considered as due to the heavier tapping to which Field 3 had been subjected in the previous experiment, but if the final results are taken into account, as below, it will be obvious that this suggestion is unsatisfactory. The two Full Spiral plots which were formed when Plot 3 was subdivided, gave final totals of 15 and 30 Brown Bast trees respectively and a subdivided plot in Plot 4 under Full Spiral tapping gave 21 Brown Bast trees. A ¾ Spiral plot from Plot 3 gave a final total of 14 and a similar plot from Plot 4 gave the same total of affected trees. A ⅞ Spiral Plot from Plot 4 gave 8 as a final total, but the previous month, eleven months after the starting of experimental tapping, only one Brown Bast tree had been found in this plot. It appears obvious that no simple explanation will suffice for the large variations that are met with.

Plots 3 and 4, after the three months preliminary tapping, were subdivided into eight plots of approximately 50 trees each. The presence of boundary drains made it difficult to obtain exact numbers, but as subdivided the plots fell within the limits of the boundary drains and supervision was thus rendered more easy. The position at this stage was :—

Plot 3	A. 55	Full Spiral
„ „	B. 51	„ „
„ „	C. 49	¾ Spiral
„ „	D. 48	½ Spiral

Total=3¼ times the circumference.

Plot 4 A. 45	Full Spiral
„ „ B. 57	¾ Spiral
„ „ C. 44	⅞ Spiral
„ „ D. 55	½ Spiral

Total=3 ⅛ times the circumference.

The number of Brown Bast trees on the change over after subdivision was .—

Plot	3	A.	2	Brown Bast	Trees.
„	„	B.	6	„	„ „
„	„	C.	3	„	„ „
„	„	D.	7	„	„ „
Plot	4	A.	4	„	„ „
„	„	B.	1	„	„ „
„	„	C.	1	„	„ „
„	„	D.	1	„	„ „

These experiments were concluded in Sept./1921 and the tables are appended. The final figures are given immediately below for comparison to show that no simple explanation can account for the differences observed.

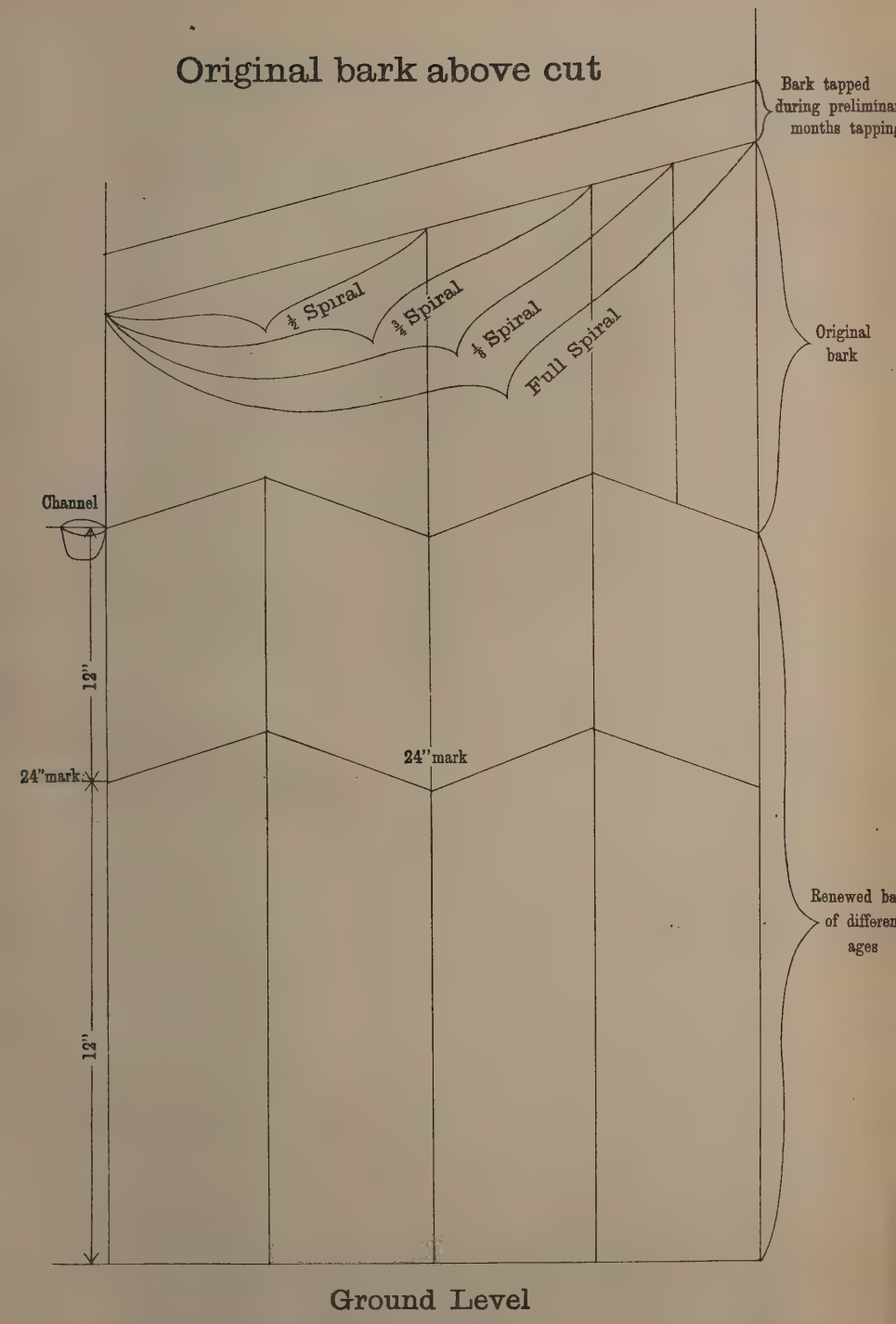
Plot	3	A.	15	Brown Bast	Trees in	Sept./21.
„	„	B.	30	„	„	„
„	„	C.	14	„	„	„
„	„	D.	21	„	„	„
Plot	4	A.	21	„	„	„
„	„	B.	14	„	„	„
„	„	C.	8	„	„	„
„	„	D.	9	„	„	„

Many interesting features were observed during the course of these experiments and can be mentioned in order.

Brown Bast extension on Individual trees.

During the experiment 133 trees out of 410 developed Brown Bast. Of these, seven were not typical although they stopped yielding latex, and in the following analysis are left out of account. The spread of the affection in each individual tree was carefully noted. The extension in area on indidual trees is rapid up to a point, then stops suddenly In the great majority of cases, if tapping is not too long continued. The nature of the retardation or stoppage is illustrated in the diagram.*

*Note;—In the diagram an obvious error has been made in marking the vertical height of the first basal panel. Instead of 12" this figure should be 24".


Original bark above cut
Bark tapped during preliminar months tappin
¼ Spiral
½ Spiral
¾ Spiral
Full Spiral
Original bark
Channel
12"
24"mark
24"mark
Renewed ba of differen ages
12"
Ground Level

In only 19 of the affected trees did the disease spread to the ground level. All the other cases, apart from those in which no extension took place after tapping was stopped, showed the disease spreading to a clearly defined position, marked by an apparent difference in age of the previously tapped bark. These positions are the old opening-up marks made when a new panel of bark is about to be tapped. Thus the trees in question initially were opened, when four to five years old, at 24", from the ground level, on a single V. The trees were tapped to the base on this panel, then a similar V was started at the same height on the opposite side. When this panel was finished and the whole circumference of the tree had been tapped down from the 24", a new V was started at the height of 36" and tapping continued down to the 24" mark, and so on. The vertical sequence, from above downwards, is virgin bark passing into young renewed bark, then into older renewed bark. The lines of demarcation between the different types of bark are usually well marked on the tree. The table below summarises the results :—

TABLE No 2.

Total number of Brown Bast trees ...	133= 33% of whole.	
Number of trees on which no extension took place after tapping was stopped ...	40= 30% of attacked trees	
Number of trees on which Brown Bast was confined to the virgin bark, i.e., did not spread through any renewed bark	20= 15%	,, ,,
Number of trees in which Brown Bast spread through the top 12" panel of renewed bark but stopped at 24" Mark ...	47= 35%	,, ,,
Number of trees in which Brown Bast spread to the base of the tree ...	19= 14%	,, ,,

In connection with these figure it may be stated that in the case of trees developing Brown Bast and the extension being stopped on cessation of tapping, the figure 10 represents trees on which absolutely no extension took place. These records are bulky and cannot be given in detail but the records of a typical plot are included to indicate the careful supervision necessary, and the nature of the work. (Page 303.)

When the affection spreads to the base of tree, the downward course varies considerably. In some cases, the affection appeared first in the area below the tapping cut then later in the renewed bark below the virgin bark at the top of the cut, eventually spreading to include all the virgin bark. In other cases the virgin bark was first attacked and extension took place from this point to the base of the tree. In one or two cases, the renewed bark well below the tapping cut became affected with Brown Bast the virgin barked being tapped above remaining healthy. The cases examined show that Brown Bast can extend both laterally and upwards, but was never seen passing from the tapping

cut upwards through recently tapped bark into untapped bark above. Lateral and upward extension is not common ; downward extension commonly takes place in narrow or broad strips which may run to the base without increase in breath.

The important features are the non-extension of Brown Bast in a high percentage of cases when tapping is stopped, and the holding up of Brown Bast extension at the places demarcated by the old opening up cuts. On two occasions, the latter feature has been reported from estates where it had drawn the Managers' attention. It would appear that some physical barrier is imposed owing to the different ages of the tissues at the line of junction or that the physiological differences between different ages of renewed bark are of such account as to almost prevent the extension of the affection from one sector to another. The suggested differences in age are more apparent than real for the cortical tissues are all formed from the same cambium and according to the rapidity of the scaling brought about by the activities of the cork-forming cambium or "phellogen", given sufficient time for renewal, the whole of the cortical tissues will be of the same age.

Examination of the cortical tissues at the junction did not afford any clue as to the probable explanation, for no significant morphological differences were observed.

Comparison of Composite Plots 3 and 4.

A general comparison between the composite plots was attempted, in order to see if any big differences could be detected when yields were calculated in units of bark removed. Plot 3 included 3-A, 3-B, 3-C, 3-D, and Plot 4 the remainder. Lengths of tapping cuts, thickness of bark and vertical height of bark removed during the experimental period, were measured. Though the results obtained can be considered as very approximate only, they provide a check to show that the two big plots could be taken as equivalent and not likely to show any differences which would interfere with the final deductions. The yield per unit inch in length worked out at .2325 for Plot 3 as against .2375 for Plot 4 ; yield per unit m/m in depth gave .80 per Plot 3 as against .825 for Plot 4. Big differences showed in the Brown Bast totals and these must be due to the treatment undergone by each particular plot.

The general position of yields in relation to incidence of Brown Bast is not well defined as a result of the analysis of the figures obtained from the sub-divided plots. From Nov. 1920 to Sept. 1921

the yield and Brown Bast figures are summarised in the table below:—

	Tapping System.	No. of trees Yielding, Nov. 1920.	No. of B.B.trees, Sept. 1921.	Av. tree Yield per. mem.	Per cent. Brown Bast.
Plot 3 A ...	F. Spiral	53	13	1.13	25
,, ,, B ...	,, ,,	43	24	1.19	50
,, ,, C ...	¾ ,,	42	11	0.88	25
,, ,, D ...	½ ,,	36	14	0.98	30
Plot 4 A ...	F. ,,	36	17	1.80	50
,, ,, B ...	¾ ,,	52	13	1.05	25
,, ,, C ...	⅞ ,,	43	7	0.75	16
,, ,, D ...	½ ,,	48	8	0.61	16

There are no significant relationships shown by the above figures. The figure of quiescent Brown Bast periods following on short periods of intense activity noted in the Part I. experiments, was well marked in most of the sub-divided plots and is indicated in the table below together with the months when the yield was well below the monthly average. The number of the months is used for convenience :—

Table No. 8.

——	3.A.	3.B.	3.C.	3.D.	4.A.	4.B.	4.C.	4.D.
Av. Tree yield -	1.13	1.19	0.88	0.98	1.80	1.05	0.61	0.61
Months of Low Av. Tree yield	3.4 5.	3.4 5.	1.2 3.4	11.12 1.2 3.4	1.2 3.	11.12 1.2 3.4	11.12 1.2 3.4	11.12 1.2 3.4
Quiescent B. Bast periods	4.5 6.7	3.4 5.	5.6 7.	12.1 2.5. 6.7	3.4 5.6	3.4 5.6 7.	12.12 1.2.3 4.5.6 7	11.12 3.4.5 6.7

Months of Low Rainfall 12. 4. 5. 6.

Though yield and Brown Bast figures show little apparent relationship, the above summary would appear to indicate that the low rainfall months are, in general, the months during which there is little Brown Bast development. It is accepted that periods of low rainfall result in decreased yields. In this particular instance the influence of the wintering period has to be considered for later work showed a substantial rise in yield during a portion of the dry weather period, following the recovery after wintering. A definite Brown Bast rise was connected with this increased yield during a period of low rainfall.

There is substantial indirect evidence to support the connection between yields and incidence of Brown Bast in the above experiments but few definite conclusions can be arrived at. However, significant observations were made which showed the necessity for prolonged observations. The records collected over a period of three years, show that in our experiments the appearance of Brown Bast in the field was extraordinarily sudden and might be placed in the series of phenomena associated with "trigger action". Daily visits to the plots were made and in the space of 24 hours there would be a sudden increase in the number of Brown Bast cases. Plot 4C which had an abnormally long quiescent period from Aug. 1920 to Sept. 1921 had only one new tree affected up to the beginning of September. On Sept. 6th seven new cases were found in this plot. This feature will be given more prominence when deating with Plots 4B and 4C. The tapping experiments were continued in these two plots so as to cover a longer period and the results will be considered in detail in the next part.

Immediately following, a typical record from Plot 3A is given. This illustrates the system of recording for all plots and the significant Brown Bast dates are noticeable. The tables of yield figures for all plots are also included.

Records from Plot 3 a. Full Spiral System Daily.

Tree No. 1.– Brown Bast was noticed on this tree before the end of the first three months tapping. Observations on the development of Brown Bast were recorded from 4.11.20.

Brown Bast in this tree extended only down to the edge of the original bark and was limited by it ; it extended throughout this area of bark but did not enter the renewed bark below. There was no extension of area from 4.11.20 to 8.9.21 when the last observations were taken.

Tree No. 2.—Brown Bast noticed in this tree before the end of the three months preliminary tapping. Disease first noted on 4.11.20 when the affection was confined to the original bark only on one side of the tree, but on the other side the disease spread through the renewed bark to within one foot of the ground.

On the 6.11.20 the Brown Bast had extended six to nine inches on three-quarters of the tree while in the quarter at the upper end of the cut it was still confined to the original bark. The renewed bark below this portion was very thin and this may have checked the extension in this area.

On the 8.11.20 there was an extension of two to eight inches and on the 10.11.20 the disease had extended to the base of the tree on one quarter and there was an extension of four to six inches on another quarter. On the upper quarter there was no extension. On the 12.11.20 there was an extension of a few inches and on the 15.11.20 Brown Bast had extended to the base on three-quarters of the circumference. The disease was still confined in the original bark on the upper quarter of the cut. From the 17.11.20 to the 24.11.20 there appeared to be no extension but examination on the 27.11.20 showed that Brown Bast had extended through the thin renewed bark on the upper quarter. On the 3.12.20 the disease had spread to the base of the tree on this quarter. The whole of the tappable portion of the tree had Brown Bast but the bark above the cut was still good. On the 26.7.21 the diseased bark was breaking away and on the 8.9.21 the tree was developing burrs

Tree No. 3.—Brown Bast was first noticed in this tree on the 30.12.20 when it extended down to the 24 inch mark, on three-quarters of the tree; the remaining quarter of the tree was free. There was no further extension until the 10.1.21 when the free quarter showed a downward extension of some five inches. On the 18.5.21 there was a slight extension below the 24 inch mark of some three to four inches but since this date there has been no further extension.

Tree No. 4.—Brown Bast was first noticed on the 30.12.20 when it had extended down to the 24 inch mark on three-quarters of the tree and from two to eight inches into renewed bark on the other quarter. No extension took place until the 19.4.21 when a small patch was found affected beneath the upper end of the cut. No extension up to 8.9.21 when the tree was forming burrs above the 24 inch mark.

Tree No. 5.—Brown bast first noticed on the 30.12.21 when it extended through the original bark and one to two inches into the renewed bark. On the 25.2.21 there was an extension downwards of eight inches on a strip three inches wide and on the 2.5.21 there was a further extension on a patch of four inches square at the side of the previous extension. Up to 8.9.21 no further extension.

Tree No. 6.—Brown bast first noticed on 30.12.20 when it had extended to the base of the tree on one quarter and in strips of from two to fifteen inches into the renewed bark on the other three quarters.

No extension until 31.1.21 when patches of a few inches extension were recorded. On the 2.5.21 the base of the tree was affected over three quarters of the circumference, while the other quarter was affected to the 24 inch mark. No extension to be reported on the 8.9.21.

Tree No. 7.—Brown bast first noticed on the 20.2.21, when it extended through the original bark and from two inches to two feet into renewed bark in a wedge shaped patch. On the 19.4.21 the disease had extended one and a half feet down the tree on a strip eight inches wide beneath the upper end of the cut. On the 2.5.21 there was extension to the base of the tree on a strip fourteen inches by two inches and on the other side of tree a small patch about three inches square was found. On the 18.5.21 there was extension on a strip ten inches long by two leaving a strip of one and a half to two inches of healthy bark between. On the 6.8.21 there was an extension on a strip twelve inches long by two inches wide. Up to the 8.9.21 there was no further extension ; on this date the Brown Bast was confined to bark above the 24 inches mark over half the tree and on the other half it had extended to within a few inches of the base of the tree.

Tree No. 8.—Brown Bast first noticed on the 1.4.21 when it extended through the original bark only at the lower end of the cut, and from one to four inches into renewed bark on the other parts of the tree. On the 20.4.21 there was an extension on a patch one and a half to four inches wide. Since there has been no development.

Tree No. 9.—Brown Bast first noticed on the 1.4.21 when it had extended eighteen inches into the renewed bark at the lower end of the cut, and on half of the tree the extension varied from just below the original bark to eighteen inches below this mark. The upper half of the cut remained healthy. On the 6.6.21 there was a further small extension but no further development since.

Tree No. 10.—Brown Bast first noticed on the 1.4.21 when it had extended one to four inches into renewed bark on half the tree. On the other half of the tree Brown Bast was limited to the original bark. On the 19.4.21 there was a small extension in the original bark but since no further development. The Brown Bast bark was splitting off on the 8.9.21.

Tree No. 11.—Brown Bast first noticed on the 1.4.21 when it had not extended beyond the original bark. A small strip of bark in the centre of the cut remained healthy. On the 8.9.21 the disease had extended throughout the original bark and about three inches into the renewed bark.

Tree No. 12.—Brown Bast first noticed on the 1.4.21 when it was limited to the original bark. On the 19.4.21 there was an

extension on a small patch three inches long. On the 8.9.21 Brown Bast was confined to the original bark on three-quarters of the tree and was half-an-inch down from the cut in the other quarter where there was no original bark. On this latter date the affected bark was splitting and breaking off.

Tree No. 13.—Brown Bast first noticed on the 1.4.21 when it had developed in a strip eight inches wide and eighteen inches down the tree in the centre of the cut. There appears to have been no extension since.

Tree No. 14.—Brown Bast first noticed on the 1.4.21 when it appeared five inches below the cut, (there was no sign of the affection on the cut) and extended to the base of the tree on a single strip. Extension has since taken place in narrow strips.

TABLE No. 4.

CASTLETON ESTATE.

BROWN BAST EXPERIMENTS.

Yields for August 1920.

—	Plot	No. of trees	Volume of latex		Latex Rubber	Lump Rubber	Scrap Rubber	Total Yields	Yield per tree per month
			gls.	pts.	lbs.	lbs.	lbs.	lbs.	
Full Spiral	3A	207	39	1	169.75	...	36	145.75	.70
„	4B	203	41	4	106.5	...	32.6	139.125	.70

Yields for September 1920.

Full Spiral	3A	207	99	7	226.6	9.00	50.7	286.3	1.4
„	4B	203	82	3¾	168	8.3	51.8	227.37	1.1

Yields for October 1920.

Full Spiral	3A	207	82	5½	174.3	11.00	33.2	218.56	1.1
„	4B	203	66	3¼	132.9	5.56	25.2	163.7	.80

TABLE No. 4—(*contd.*)

CASTLETON ESTATE.

Yields from Brown Bast Experiments August to October, 1920.

Plot No.	System of tapping.	Month.	No. of trees.	No. of Brown Bast trees.	No. of control trees.	Total No. of trees tapped.	Total Rubber. lbs.	Average Yield per tree.
3A	Full Spiral		55	2	...	53	39.25	.75
B	„ „		51	7	1	43	33.56	.77
C	¾ „		49	5	2	42	25.30	.60
D	½ „	Nov.	48	10	2	36	22.30	.61
4A	Full „	1920	45	7	2	36	36.00	1.00
B	¾ „		57	3	2	52	31.9	.61
C	⅞ „		44	1	0	43	21.06	.49
D	½ „		55	4	3	48	19.25	.40
3A	Full Spiral		55	6	4	45	44.6	.90
B	„ „		51	11	2	38	36.25	.90
C	¾ „		49	7	2	40	28.00	.70
D	½ „	Dec.	48	13	4	31	24.5	.79
4A	Full „		45	8	3	34	53.75	1.59
B	¾ „		57	5	4	48	40.30	.86
C	⅞ „		44	1	0	43	27.30	.63
D	½ „		55	4	3	48	26.9	.56
3A	Full Spiral		55	6	4	45	54.9	1.22
B	„ „		51	11	2	38	42.125	1.11
C	¾ „		49	8	2	39	26 25	.67
D	½ „	Jan.	48	13	4	31	23.60	.76
4A	Full „	1921	45	10	5	30	42.90	1.43
B	¾ „		57	7	6	44	36.70	.83
C	⅞ „		44	1	0	43	24.50	.56
D	½ „		55	4	3	48	22.90	.48
3A	Full Spiral		55	7	4	44	42.75	.97
B	„ „		51	12	2	37	34.70	.92
C	¾ „		49	8	2	39	23.30	.59
D	½ „	Feb.	48	13	4	31	20.25	.65
4A	Full „		45	11	5	29	39.125	1.35
B	¾ „		57	10	9	38	31.125	.82
C	⅞ „		44	1	0	43	23.8	.55
D	½ „		55	5	4	46	20.00	.31
3A	Full Spiral		55	7	4	44	38.125	.86
B	„ „		51	15	2	34	29.125	.80
C	¾ „		49	9	2	38	20.50	.54
D	½ „	March	48	15	4	29	16.60	.51
4A	Full „		45	15	5	25	35 .0	1.40
B	¾ „		57	13	9	35	27.85	.74
C	⅞ „		44	2	0	42	20.8	.48
D	½ „		55	6	4	45	17.8	.39

TABLE No. 4—(*contd.*)

CASTLETON ESTATE.

Yields from Brown Bast Experiments August to October, 1920.

Plot No.	System of tapping.	Month.	No. of trees.	No. of Brown Bast trees.	No. of control trees.	Total No. of trees tapped.	Total Rubber. lbs.	Average Yield per trees.
3A	Full Spiral	April 1921	55	14	4	37	36.75	.99
B	,, ,,		51	16	2	33	30.30	.92
C	¾ ,,		49	9	2	38	20.50	.54
D	½ ,,		48	15	4	29	18.37	.63
4A	Full ,,		45	16	5	24	41.50	1.70
B	¾ ,,		57	13	9	35	32.7	.94
C	⅞ ,,		44	2	0	42	26.44	.63
D	½ ,,		55	6	4	45	21.25	.47
3A	Full Spiral	May	55	14	4	37	50.60	1.36
B	,, ,,		51	16	2	33	39.00	1.18
C	¾ ,,		49	12	2	35	31.75	.90
D	½ ,,		48	18	4	26	29.00	1.11
4A	Full ,,		45	16	5	24	58.30	2.41
B	¾ ,,		57	13	9	35	43.125	1.23
C	⅞ ,,		44	2	0	42	40.06	.95
D	½ ,,		55	6	4	45	37.44	.83
3A	Full Spiral	June	55	14	4	37	44.75	1.20
B	,, ,,		51	20	2	29	38.44	1.23
C	¾ ,,		49	12	2	35	32.44	.92
D	½ ,,		48	18	4	26	30.25	1.16
4A	Full ,,		45	16	5	24	33.50	1.39
B	¾ ,,		57	13	9	35	30.7	.87
C	⅞ ,,		44	2	0	42	29.9	.71
D	½ ,,		55	6	4	45	25.9	.57
3A	Full Spiral	July	55	14	4	37	41.37	1.11
B	,, ,,		51	21	2	28	39.00	1.39
C	¾ ,,		49	12	2	35	36.37	1.04
D	½ ,,		48	18	4	26	33.00	1.26
4A	Full ,,		45	18	5	22	46.37	2.11
B	¾ ,,		57	13	9	35	47.37	1.71
C	⅞ ,,		44	2	0	42	41.6	.99
D	½ ,,		55	6	4	45	33.85	.75
3A	Full Spiral	August	55	14	4	37	61.7	1.66
B	,, ,,		51	21	2	28	53.44	1.89
C	¾ ,,		49	12	2	35	59.00	1.68
D	½ ,,		48	18	4	26	44.9	1.74
4A	Full ,,		45	18	5	22	62.125	2.83
B	¾ ,,		57	13	9	35	57.125	1.63
C	⅞ ,,		44	2	0	42	52.56	1.25
D	½ ,,		55	6	4	45	47.06	1.04

TABLE No. 4—(*contd.*)

CASTLETON ESTATE.

Yields from Brown Bast Experiments August to October, 1920.

Plot No.	System of tapping.	Month.	No. of trees.	No. of Brown Bast trees.	No. of control trees.	Total No. of trees tapped.	Total Rubber. lbs.	Average Yield per trees.
3A	Full Spiral	) (	55	15	4	36	48.125	1.33
B	„ „	) (	51	30	2	19	35.56	1.67
C	¾ „	) (	49	14	2	33	48.125	1.45
D	½ „	) Sept. (	48	21	4	23	33.50	1.45
4A	Full „	) 1921 (	45	21	5	19	47.50	2.50
B	¾ „	) (	57	14	9	34	44.37	1.30
C	⅞ „	) (	44	8	0	36	40.60	1.12
D	½ „	) (	55	9	4	42	40.20	.95

CONTINUED TAPPING EXPERIMENTS ON PLOTS 4 B. AND 4 C.

In view of the endeavours of Rands (11) to obtain trees of *Hevea brasiliensis* immune to Brown Bast, the records of Plot 4 C. over the tapping period from August 1920 to September 1921, were of some significance. It was decided to continue the experiments to see if the sudden rise in number of Brown Bast cases on September 6th in this plot indicated a definite change in Brown Bast behaviour. Plot 4 B. had functioned normally in this connection and tapping was continued in this plot to control the further observations to be made on Plot 4 C. The table below gives the essential details.

TABLE No. 5.

FOR LONG-TAPPING PERIOD FOR PLOTS 4B AND 4C.

From November, 1920 *to December*, 1922. *Duration* 26 *months.*

Plot and tapping system.	Date.	No. of trees.	No. of Yielding trees.	No. of B. Bast trees.	No. of Control trees.	Total Yield.	Average Monthly Yield.	Total Rise in B. Bast trees.	Special B. Bast Date.
4B ¾ Spiral	Nov.	57	52	3	2	31.90	.61		
4C ⅞ „	1920	44	48	1	0	21.06	.49	2	
4B ¾ „	Dec.	57	48	5	4	40.30	.86		
4C ⅞ „		44	43	1	0	27.30	.63	2	17.12.20
4B ¾ „	Jan.	57	44	7	6	36.70	.83		
4C ⅞ „	1921	44	43	1	0	24.50	.56	2	5.1.22

TABLE No. 5—(*contd.*)

FOR LONG-TAPPING PERIOD FOR PLOTS 4B AND 4C.

From November, 1920 to December, 1922. Duration 26 months.

Plot and tapping system.	Date.	No. of trees.	No. of Yielding trees.	No. of B. Bast trees.	No. of Control trees	Total Yield.	Average Monthly Yield.	Total Rise in B. Bast trees.	Special B. Bast Date.
4B ¾ „	Feb.	57	38	10	9	31.125	.82		
4C ⅞ „		44	43	1	0	23.80	.55	3	1.2.21
4B ¾ „	March	57	35	13	9	27.85	.74		
4C ⅞ „		44	42	2	0	20.80	.48	4	31.3.21
4B ¾ „	April	57	35	13	9	32.70	.94		
4C ⅞ „		44	42	2	0	26.44	.63	...	
4B ¾ „	May	57	35	13	9	43.125	1.23		
4C ⅞ „		44	42	2	0	40.06	.95	...	
4B ¾ „	June	57	35	13	9	30.70	.87		
4C ⅞ „		44	42	2	0	29.90	.71	...	
4B ¾ „	July	57	35	13	9	47.37	1.71		
4C ⅞ „		44	42	2	0	41.06	.99	...	
4B ¾ „	Aug.	57	35	13	9	57.125	1.63		
4C ⅞ „		44	42	2	0	52.53	1.25	...	
4B ¾ „	Sept.	57	34	14	9	44.37	1.30		
4C ⅞ „		44	36	8	0	40.60	1.12	7	6.9.21
4B ¾ „	Oct.	57	36	14	7*	37.63	1.04		
4C ⅞ „		44	36	8	0	23.94	.66	...	
4B ¾ „	Nov.	57	36	14	7	47.19	1.31		
4C ⅞ „		44	33	11	0	45.38	1.37	3	9.11.21
4B ¾ „	Dec.	57	32	18	7	48.31	1.51		
4C ⅞ „		44	33	11	0	46.38	1.41	4	17.12.21
4B ¾ „	Jan.	57	30	20	7	32.88	1.10		
4C ⅞ „	1922	44	32	12	0	33.56	1.05	3	
4B ¾ „	Feb.	57	30	20	7	30.75	1.02		
4C ⅞ „		44	30	14	0	30.44	1.01	2	

* Two control trees put into ¾ Spiral Plot to make up equal number of yielding trees at the end of September on continuation of experiment.

TABLE No. 5—(*contd.*)

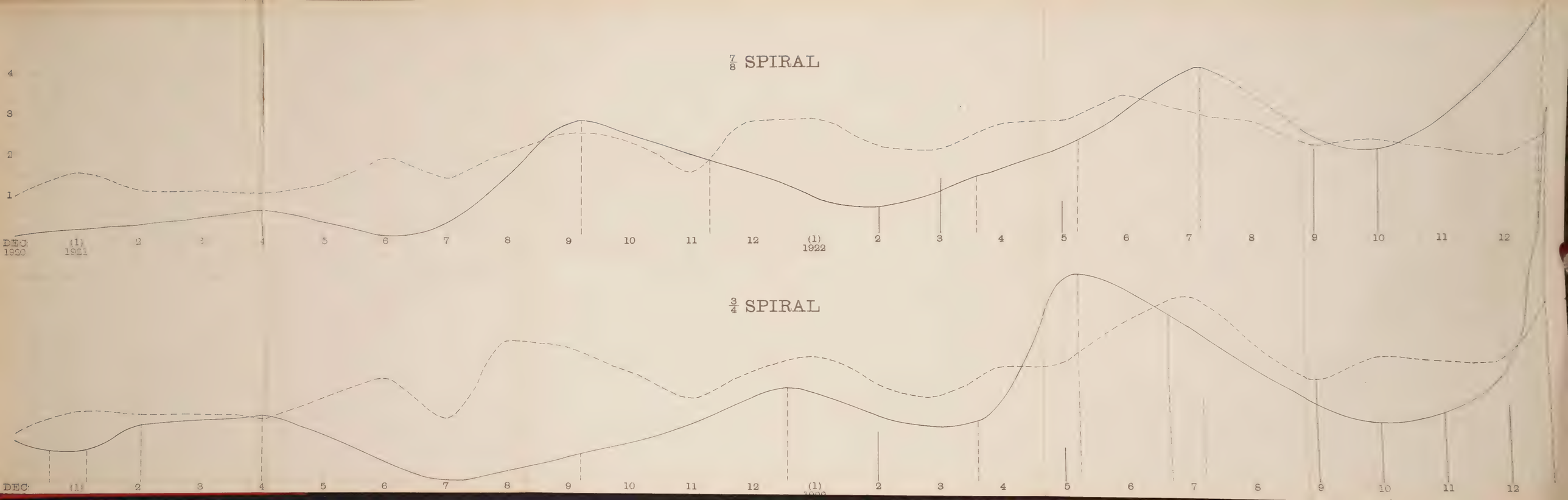
FOR LONG-TAPPING PERIOD FOR PLOTS 4B AND 4C.

From November, 1920 to December, 1922. Duration 26 Months.

Plot and tapping system.	Date.	No. of trees.	No. of Yielding trees.	No. of B. Bast trees.	No. of Control trees.	Total Yield.	Average Monthly Yield.	Total Rise in B. Bast trees.	Special B. Bast Date.
4B ¾ „	March	57	28	22	7	37.88	1.35		
4C ⅞ „		44	28	16	0	37.81	1.35	4	18.3.22
4B ¾ „	April	57	27	23	7	37.50	1.39		
4C ⅞ „		44	27	17	0	36.88	1.37	2	
4B ¾ „	May	57	22	28	7	41.75	1.90		About
4C ⅞ „		44	26	18	0	42.19	1.62	6	7.5.22
4B ¾ „	June	57	18	32	7	39.75	2.21		
4C ⅞ „		44	26	18	0	38.00	1.46	4	20.6.22
4B ¾ „	July	57	16	34	7	26.19	1.64		
4C ⅞ „		44	21	23	0	28.31	1.35	7	6.7.22
4B ¾ „	Aug.	57	14	36	7	16.63	1.19		
4C ⅞ „		44	19	25	0	19.81	1.04	4	
4B ¾ „	Sept.	57	13	37	7	19.94	1.53		
4C ⅞ „		44	17	27	0	18.88	1.11	3	
4B ¾ „	Oct.	57	11	39	7	16.00	1.45		
4C ⅞ „		44	17	27	0	17.00	1.00	2	
4B ¾ „	Nov.	57	8	42	7	11.88	1.48		
4C ⅞ „		44	16	28	0	14.44	.90	4	
4B ¾ „	Dec.	57	2	48	7	6.13	3.06		
4C ⅞ „		44	8	36	0	16.00	2.00	14	17.12.22

The "trigger action" nature of the Brown Bast increase is well shown in Table No. 5. Up to the end of 1922 the sharp rise following a quiescent period is in evidence and must have considerable significance. The curves for yield and Brown Bast development are given below.

In considering increases in average yield figures, it should be remembered that as tapping is continued from the 36" mark downwards, the circumference increases appreciably and the tapping cuts increase in length with a presumed corresponding increase in yield.


7/8 SPIRAL
4
3
2
1
DEC 1920
(1) 1921
2
3
4
5
6
7
8
9
10
11
12
(1) 1922
2
3
4
5
6
7
8
9
10
11
12
3/4 SPIRAL
DEC
(1)
2
3
4
5
6
7
8
9
10
11
12
(1)
2
3
4
5
6
7
8
9
10
11
12

Again it may be noted that if the special Brown Bast dates appear towards the middle of the month some correction in average tree yield is necessary. These corrections resulted in a change in the second decimal figure only and so were of little importance.

The dotted curve represents Average Tree Yield per month (A.T.Y.M.) and the line curve Percentage Increase in Number of Brown Bast Trees (P.I.B.B.) in relation to actual number of trees in tapping. The number of trees in tapping decreases month by month as more trees succumb to Brown Bast and are taken out of tapping. The ordinates for the P.I.B.B. are represented as dotted for the Special Brown Bast dates and full lines for ordinary increases which were observed during the month; these latter are totalled and the vertical column erected for the last day of the month.

Owing to a typewriting error escaping notice whilst dealing with the masses of figures the P.I.B.B. curves are not absolutely accurate as from May, 1922 to December, 1922 onwards. The actual percentage increases in Brown Bast for the months mentioned are given below. The error makes no difference to the general trend of the curve and does not affect the argument as the tabled figures show. These indicate the large percentage increases in Brown Bast in both plots about May, June and July, which though months of low rainfall showed increased Average Monthly Tree Yields over previous months. This period of intense Brown Bast activity is followed by a period of ordinary increases, with no special Brown Bast dates, up to November, December, 1922, when another burst followed.

	¾ Spiral.	⅞ Spiral.
May ...	5 in 27 = 19%	1 in 27 = 4%
June ...	4 „ 22 = 18%	0 „ 26 = —
July ...	2 „ 18 = 11%	5 „ 26 = 20%
Aug. ...	2 „ 16 = 12½%	2 „ 21 = 10%
Sept. ...	1 „ 14 = 7%	2 „ 19 = 10%
Oct. ..	2 „ 13 = 15%	0 „ 11 = —
Nov. ...	3 „ 11 = 27%	1 „ 17 = 5%
Dec. ...	6 „ 8 = 76%	8 „ 16 = 50%

Accepting the Special Brown Bast dates as of more than ordinary significance it will be seen that the P.I.B.B. curves follow one another closely as from September 9th, 1921, up to which date the ⅞ Spiral plot had shown marked resistance to the onset of Brown Bast, as from December 1910 to September 1921. In general it would appear that there is a well marked rhythm, corresponding with the poor and good yielding periods of the year; the poor yielding period includes the approach of the wintering season, the period of wintering and a short period afterwards until the tree recovers its full activities. The good yielding period covers the remainder of the year and is influenced largely by climatic conditions.

In particular, the ⅞ Spiral plot shows a decidedly low Average Tree Yield per Month coupled with strong resistance to the onset of Brown Bast. Comparison of the curves of the two plots has to be made on the reckoning that the ⅞ Spiral plot has 12½ % more bark removed than the ¾ Spiral; the Average Monthly Tree Yield from the ⅞ Spiral plot is lower, on the whole, from December, 1920 to September, 1921, in spite of the greater amount of bark removed.

The sudden rise in Percentage Number of Brown Bast cases on September 6th, 1920 in Plot 4 C. appears directly correlated with a sudden increase in Average Tree Yield per month. Up to August 1921 this was always below 1.00. This figure increased in August 1921 and September 1921 to 1.25 and 1.21 respectively; after November 1921 the figure remained above 1.00 until November 1922, and during this period the plot developed Brown Bast in a manner similar to other plots. If a comparison between the two curves plotted for yield is made for the period after September, 1921, no big differences can be found excepting when a big increase signifies a big Brown Bast increase as in May, June and July for the ¾ Spiral plot. A close study of these curves both from a a general and particular point of view, indicates some close connection between yields and Brown Bast incidence. For the particular area in question, strong evidence is brought to show that Brown Bast and excessive yielding are directly connected. The macroscopic appearance of Brown Bast is in the nature of a stimulus followed by a sudden release, and during certain periods of the year there is practically no Brown Bast development. In 1919 sudden increases in Brown Bast cases took place in September and December. In 1920 small increases took place in November and December, and in 1921 in January, February and March. The next five months, in general were quiescent, but a sudden rise took place again in September. November and December/1921, January, February, March and April/1922 show average increases but May, June and July, in the previous year quiescent months. were heavy Brown Bast months followed by a quiet period until December ; only a small increase was reported in September/22 though the previous two years this month was a notably heavy Brown Bast month. In December/22, when only twenty-four trees were still yielding, the " trigger action" phenomenon was most pronounced, fourteen fresh cases being reported on December 17th.

As far as the records go, the quiescent Brown Bast periods do not fall in any particular months, though had 1922 observations supported those obtained in previous years it would have been possible to state that the months of and immediately following wintering were months of low Brown Bast development. The records indicate that if the yield figures are high in consecutive months there is likely to be a large increase in number of Brown Bast cases, this increase being followed by a comparatively quiet period. Also that high yields may be obtained in months of low rainfall, as in May, 1922 with 5.24 ins., June, 1922 with 3.05 ins. and July, 1922 with 2.84 ins. and as indicated above, these were heavy Brown Bast months.*

More work is required clearly to elucidate the correlations, but there seems little reason to doubt the close connection between Brown Bast development and the amount of latex extracted. It should be clearly understood that the term " excessive yielding" does not imply that the highest yielding plots are less resistant to Brown Bast, but that under the general growth conditions, which may vary considerably even in contiguous plots, a limit is set on the amount of latex which can be extracted without setting up conditions favourable for the

*See Rainfall records at end of article.

development of Brown Bast. This limit will be higher or lower as the conditions are more or less favourable for yielding.

The features to which attention has been specially drawn cannot be lucidly explained without accepting some "physiological theory," and these have appeared so constantly over an extended experimental period that it is probable that further support will be forthcoming when they are repeated on other estates with different soil conditions; in this connection it is advisable to emphasise that our results can be taken to apply only to conditions similar to those on Castleton Estate. We are of the opinion that environment plays a prominent role in questions relating to yield, and small environmental changes, may result in large modifications of experimental results. It will be obvious to other workers in this field that results from a single plot are not likely to prove of much value.

We intend to attempt an explanation on the basis of exhaustion and it might be convenient to make our attitude clear at this point. Many investigators have suggested a similar explanation, but most have inclined to the view that the elaborated food materials lost by the extraction of the latex are of supreme importance. The writers are of the opinion that the water constituent of the latex is of first importance in this problem; that the normal physico-chemico relationships which govern the distribution of water throughout the plant tissues are seriously disturbed when amounts of latex beyond a certain limit, are being extracted. As a result of this disturbance the macroscopic symptoms known as Brown Bast appear in the cortical tissues.

The facts obtained contradict Keuchenius's statement (6) that "the theory of high yielding with consequent exhaustion, and "large wounding influence cannot account for the features observed, "as in such cases of heavy tapping experiments *the disease figure "would increase largely, which is not the case.*" He states this opinion in a synopsis dealing with the factors which are insufficiently accounted for by a "physiological theory", and the opinion is based on three heavy tapping experiments which were each continued for one month only. A criticism of the results of experiments of such short duration is superfluous in the light of our results, which surely render the position of Keuchenius untenable on this important point.

Many observers have dealt with the Brown Bast problem in a general way and have considered the various factors which might influence the incidence of the disease. These factors, Rainfall, Light and Moisture, Age of the Trees, Height of Tapping Cut etc. are all interconnected with yield, yet in the majority of experiments conducted with a view to elucidating these factors, no yield figures are given. Keuchenius (6) does not give yield figures for any of the following sections (*a*) Rainfall and Frequency of the disease (*b*) Light, Moisture and Frequency of the disease (*c*) Age of the trees and Frequency of the disease (*d*) Height of Tapping Cut and Frequency of the disease (*e*) Connection between Tapping System and Frequency of the disease (*f*) Tilling of the Soil and Frequency of the disease. He considers that some of these factors (presumably apart from question of yield) have considerable influence on the incidence of Brown Bast. We have dealt with Rainfall and shown decisively that heavy Brown

Bast periods may coincide with dry periods, if the yield continues high over the dry period.

Keuchenius says with regard to this question, "The effect of the "rainfall, mentioned above, in my opinion, should be directly con- "nected with increase of moisture (in soil and air) and the decrease "in intensity of the sunshine due to clouding of the sky. The high "disease percentage on innumerable mountain estates in Java, espe- "cially when coffee is interplanted in the shade of the Hevea as a "secondary cultivation, is in agreement herewith. The influence of "light and moisture, both of which factors to a certain extent are "interdependent, meanwhile also makes its presence felt in other ways "than an increase of the disease percentage.....A number of "observations have convinced me that with lack of light and with "increase of moisture, Brown Bast occurs in far more serious form "etc."

In Malaya, at least, conditions as depicted in the above quotation would result in definite increases in yield. Planters claim an increased yield of some 20% if tapping can be started an hour earlier in the morning and on misty mornings the trees drip latex for considerably longer periods than on clear days when the full effect of the sun is felt.

PART III.

Further Tapping Experiments.

The previous experiments opened up many questions on which further information was desirable. The following points were considered important.

(1). The stoppage of Brown Bast extension at definite places delimited by an apparent difference in age of renewed bark, i.e. the old opening-up cuts. This feature might be of practical importance in the question of treatment.

Plot A.—This plot was first tapped for two months on a Full Spiral at a height of 27" then a similar cut was started 9" above; a depression of two inches of recently renewed bark was thus inserted, separating and isolating the bark below from that above, in which Brown Bast would appear as the heavy tapping was carried forward. The previous experiments had suggested that the affected areas might be limited by interposing a recently renewed area; in this manner the untapped areas below might be protected.

Plot B.—Similar to Plot A, but a narrow depression of half-an-inch only of recently renewed bark interposed between the upper and lower bark areas.

(2). To ascribe the proper significance resulting from the amount of latex extracted as against the wounding influence set up during the tapping operation

Plot C.—An attempt to obtain evidence re (2) was made as follows. It is commonly assumed, and practice supports the assumption, that tapping during the heat of the day results in decreased yields as compared with tapping in the early hours. Plot C was tapped on a Full Spiral, once daily, at mid-day, during the experiment, and accepting the above statement, this plot should have given decreased yields though the wounding influence would be equivalent to that in other plots, tapped early.

Plot D.—This plot was tapped lightly, once daily, on a Full Spiral, as a control for Plots C. and E. Light tapping, involving only the less tender, outer cortical tissues, would result in less irritation and decreased yield.

Plot E.—This plot was set up to endeavour to obtain evidence re (2). Tapped similarly to the above plots and the latex coagulated on the tapping cut with a 2½ % solution of Acetic Acid.

(3). Is any special significance to be attached to the system of tapping in the abnormal plot, i.e. ⅞ Spiral.

Plot F.—Put under a ⅞ Spiral to see if the previous results could be supported.

Plot G.—This plot was put in on November, 1st 1921 as a control for Plot B. The trees were tapped on a ½ Spiral. Following the method of treatment developed by Keuchenius (6), a deep depression, cut down to the wood, was interposed to protect the lower bark areas, previous to the experimental tapping. This depression was narrow but deep enough to completely isolate the bark below from that being tapped above.

The plots contained 50 trees each and all were subjected to the three months preliminary heavy tapping to test for abnormalities as regards their behaviour to Brown Bast. Plot G, is not included in these remarks, but the records are given in the final tables at the end of this portion for purposes of comparison if necessary.

Summary of Total Yields and Brown Bast Trees.

(1). Three months preliminary heavy tapping September, 1st 1921 to November, 31st 1921.

Plot	Brown Bast Trees.	Total Yields.
A	10	117.45 lbs.
B	9	159.01 ,,
C	9	135.88 ,,
D	12	138.95 ,,
E	10	144.87 ,,
F	13	143.82 ,,

(2). Heavy Tapping from December, 1st 1921 to April, 31st 1922.

Plot.	Brown Bast Trees			Increase in number of B.
	Apr. 31st.	May 31st.	Total Yields.	Bast Trees.
A	29	29	133.26 lbs.	19
B	19	20	179.89 ,,	11
C	18	29	169.63 ,,	20
D	13	16	83.51 ,,	4
E	17	23	125.82 ,,	13
F	16	18	166.89 ,,	5

The taking of records was stopped on May 1st, but tapping was continued through May to see if more trees became affected with Brown Bast. The April and May columns above for Plots C and E show the big differences which may quickly appear in short term experiments and emphasise the necessity for carrying on Brown Bast tapping experiments over a sufficiently long period in order to obtain trustworthy results.

The general results are concordant with the experimental evidence obtained previously. Out of 350 trees, 138 (39%) developed Brown Bast. The affection was confined to the original bark in 122 trees; in only 16 cases did Brown Bast spread to any extent.

The evidence obtained in these experiments showed conclusively that if Brown Bast is detected sufficiently early and tapping is stopped immediately, there is little extension in the great majority of cases. Many cases were noted with the affection extending half-an-inch to one inch downwards from the cut. Tapping was stopped for a month and on resumption there was usually no signs of Brown Bast, but when tapping was continued, some cases developed the affection more seriously while others remained free. This observation is of importance in connection with the attempts of Rands (11) to establish trees immune to Brown Bast.

Though the above remarks suggests that Brown Bast can be checked by careful supervision, it should be noted that, under plantation conditions, the same careful supervision to each individual tree could not be given, and it is doubtful if we could hope for similar results.

Plots A and B and G gave positive evidence with reference to preventing extension of Brown Bast on individual trees. Plot A, with a wide depression at ordinary tapping depth, only two out of twenty-five showed signs of Brown Bast below the depression. Plot G, with a deep narrow cut down to the wood, showed complete isolation in all cases. Plot B, with a narrow depression at ordinary tapping depth, fourteen out of twenty cases passed across the depression.

These results are interesting. Keuchenius (6), in developing his theory as to the origin of Brown Bast, attaches some importance to the successful isolation of Brown Bast by means of deep cuts to the wood. The above results show that practically the same end is attained without deep cuts but the isolation cuts at ordinary tapping depth must be sufficiently wide to function successfully.

It is worthy of remark that a considerable reduction in amount of total rubber is found when wide or deep depressions are utilised as isolation cuts, as in Plots A and G, for when the cut being tapped comes within two inches of the depressions, the majority of the trees go dry or yield only a small amount, though Brown Bast cannot be detected. Such cases provide instances of large wounding influence with a decrease in yield, but no increase in Brown Bast, indicating that the amount of latex extracted is the factor of greatest importance in the initiation of Brown Bast. The narrow depression in Plot B, did not interfere with the yield in this manner.

Positive evidence was hoped for from Plot C, but only a slight falling off in yield was found as compared with the remaining plots, which were tapped in the early hours of the morning. As pointed out previously, it is evident that estate practice does not prove a reliable guide when heavy tapping with a correspondingly high yield is the order of the day.

The results from Plot D were expected. Light tapping means less wounding and decreased yields because the internal, rich-in-latex layers are not touched by the knife.

Again the ⅞ Spiral plot behaves abnormally when the change-over is made. Tapping was carried on for a short period only in these experiments; the previous records show that little can be gathered unless the experiments are carried over a long period, the more extended the better. It would be dangerous to consider the results obtained in this plot as significant.

The above observations afford a probable explanation of a problem which has puzzled most investigators dealing with this affection. In the early days of the rubber industry, when large numbers of superimposed cuts were put up the tree to a height of 10-15 ft., Brown Bast was apparently unknown. Harmsen has collected figures (Vide Rands. 11) showing that with two superimposed cuts Brown Bast makes its appearance on the top cut first in 80% of cases. It is probable, that in the early days, the top cuts became affected with Brown Bast, but each tapping area below acted as an isolation barrier, preventing the appearance of the affection in the lower panels. Again, little care was taken in the matter of bark excision and it is possible that affected bark was removed almost as rapidly as it appeared.

The same features to which attention was directed in the previous experiments regarding the "trigger action" appearance of Brown Bast, were noticable in these plots. The figures given below show the special Brown Bast dates for Plots A and B. The quiescent period is not well marked because of the limited tapping period, but the totalled figures, as below, show that the monthly increase was fairly large, but during March and April only two fresh cases were reported. The monthly increases were:—

November.	December.	January.	February.	March.	April.
14	25	18	11	8	2

The falling-off in numbers is clearly shown by the totalled figures and indicates the typical rise and fall period already noted.

Special Brown Bast Dates for Plots A and B.

B. Bast dates	6-10-21.	4-11-21.	28-11-21.	6-1-22.	4-2-22.	2-3-22.
Plot A	1	4	10	6	5	6
Plot B	2	4	4	5	1	2

TABLE No. 6.

Month.	No. of trees.	No. of Brown Bast trees.	No. of Yielding trees.	Total Yield.	Average yield per tree per mensem.	Plot.
1921 September	50	...	50	37.38	0.75	A
	50	...	50	41.63	0.83	B
	50	...	50	38.00	0.76	C
	50	...	50	43.88	0.88	D
	50	...	50	45.00	0.90	E
	50	...	50	46.63	0.93	F
October	50	...	50	34.38	0.69	A
	50	3	47	60.50	1.29	B
	50	4	46	49.00	1.06	C
	50	3	47	47.88	1.02	D
	50	1	49	51.31	1.05	E
	50	3	47	50.81	1.08	F
November	50	2	48	45.69	0.95	A
	50	6	44	56.88	1.29	B
	50	9	41	48.88	1.19	C
	50	7	43	47.19	1.10	D
	50	5	45	48.56	1.08	E
	50	9	41	46.38	1.13	F
	50	...	50	31.06	0.62	G
December	50	10	40	40.69	1.01	A
	50	9	41	43.13	1.05	B
	50	9	41	42.50	1.04	C
	50	12	38	12.25	0.32	D
	50	10	40	24.00	0.60	E
	50	13	37	33.69	0.91	F
	50	2	48	24.50	0.51	G
1922 January	50	16	34	26.75	0.78	A
	50	15	35	34.94	1.00	B
	50	11	39	34.13	0.87	C
	50	12	38	17.69	0 46	D
	50	13	37	24.19	0.65	E
	50	14	36	31.63	0.88	F
	50	3	47	21.19	0.45	G
February	50	22	28	25.19	0.90	A
	50	16	34	36.06	1.06	B
	50	14	36	34.44	0.96	C
	50	12	38	17.25	0.45	D
	50	13	37	27.00	0.73	E
	50	16	34	32.88	0.97	F
	50	4	46	19.50	0.42	G

TABLE No. 6—(*contd.*)

Month.	No. of trees.	No. of Brown Bast trees.	No. of Yielding trees.	Total Rubber.	Average yield per tree per mensem.	Plot.
1922 March	50	28	22	23.63	1.07	A
	50	18	32	35.63	1.11	B
	50	18	32	32.06	1.00	C
	50	13	37	19.25	0.52	D
	50	17	33	25.00	0.75	E
	50	16	34	41.25	1.21	F
	50	7	43	14.01	0.32	G
April	50	29	21	17.00	0.81	A
	50	19	31	29.13	0.94	B
	50	18	32	26 50	0.80	C
	50	13	37	17.13	0.46	D
	50	17	33	25 63	0.78	E
	50	16	34	27.44	0.81	F
	50	7	43	15.63	0.36	G

PART IV.

TAPPING EXPERIMENTS.

The previous experiments left a large number of trees which had been slightly attacked by Brown Bast. The opportunity arose to make a comparison between these and others not previously affected. The suggestion was made that a slight attack might confer some immunity, as in many human diseases.

The high-yielding "mother trees", utilised as the source from which Bud-grafts have been started in the attempt to gain trees of higher yielding capacities, usually succumb to Brown Bast. The behaviour of the slightly Brown Basted trees under further tapping might be of interest and give a line to the future behaviour of "daughter" bud grafted trees.

Another point was the endeavour of Rands (11) to develop a strain of *Hevea brasiliensis* immune to Brown Bast, the selection being made according to the behaviour of high yielding trees subjected to heavy tapping. It has been noted above that Brown Bast trees, detected in the earliest stages, often recover after one month's rest, and show no signs of the affection on resumption of tapping. Now if any such trees should prove to be comparatively high yielders and maintain their capacity for high yielding over a fairly lengthy period after recovery, the work carried out by Rands along the lines adopted would be practically negatived.

The tables are given below, with the yield figures in ounces. The totalled yields for January in the two series show little difference.

The final Brown Bast figures show that the trees previously affected with Brown Bast develop the symptoms more quickly than the trees which have not been previously affected. Even in these small plots, the quiescent months are noticable ; from April to September in the plot of healthy trees and from March to October in the plot of previously affected trees.

The results, in general, show that trees having suffered from Brown Bast are more readily attacked than healthy trees and it might be expected that "daughter trees" developed by vegetative propagation from "mother trees" which show this affection will be more readily affected than others which have been developed from stock unaffected by Brown Bast. Further evidence will be offered below to show that the extremely high yielders in a plot of trees all yielding above the average, are the first to become affected with Brown Bast.

Rands methods to obtain immune trees resistant to Brown Bast, are based on trees severely overtapped (see Part 11.) *for at least two months.* Trees which do not contract Brown Bast during this period he considers may be sufficiently immune to form the parent stock from which to breed. The results from Tree No. 10 in the plot of previously affected trees, effectually undermines this basis. This tree is reopened after recovery ; continues as a comparatively high yielding tree for twelve months without a recrudescence of the attack, while trees unaffected previously, give lower yields during the twelve months, but become affected with Brown Bast. Such evidence leads to the suggestion that Rands endeavours to obtain immune trees on the basis adopted are not likely to prove successful.

TABLE No. 7.

Healthy trees.

Month.	1	2	3	4	5	6	7	8	9	10	Brown Bast trees.
Jan.	24.48	14.96	21.50	39.80	35.07	18.21	25.60	33.72	18.38	34.34	1
Feb.	16.93	7.81	13.95	34.89	24.73	*6.60	15.81	24.37	12.04	23.13	1
Mar.	17.52	11.32	17.70	38.30	25.77	*5.16	15.37	31.69	13.45	25.88	1
April	18.92	6.01*	11.67*	28.69	23.40	*4.72	11.67	17.71	10.28	19.45	3
May	26.36	9.30*	14.63*	43.81	27.79	*6.26	15.35	24.75	8.89	20.35	3
June	20.00	...	11.00*	36.00	16.00	...	12.00	20.00	8.00	16.00	3
July	24.00	...	16.00*	45.00	28.00	...	16.05	30.00	12.25	25.00	3
Aug.	26.00	...	20.00*	42.38	26.00	...	12.06	23.03	10.38	22.03	3
Sept.	23.21	...	23.21*	35.33	16.06	...	18.28	24.19	10.46	11.06	3
Oct.	21.50	...	17.44*	55.06	...	...	20.31	25.40	15.63	...	5
Nov.	7.31*	...	7.19*	37.25	...	...	16.50	20.00	17.50	...	6
Dec.	...	...	...	42.50	...	...	11.75	20.50	11.00	...	6

* Brown Bast trees still yielding latex.

296.06 Total yield in January.

TABLE No. 7—(*contd.*)

Trees with previous Brown Bast.

Month.	1	2	3	4	5	6	7	8	9	10	Brown Bast trees.
Jan.	20.95	22.44	33.60	25.74	35.10	11.42*	24.42	31.31	30.86*	44.40	2
Feb.	13.65	16.89	35.02	1.75*	41.00	.19*	22.16	28.24	2.00*	42.78	3
Mar.	14.58	16.34	24.18*	.65*	5.97*	1.07*	20.57	33.54	.19*	54.52	5
April	12.56	14.36	...	...	...	...	15.10	24.19	...	37.16	5
May	13.48	12.77	6.48*	...	...	...	26.87	15.57	3.19*	42.37	5
June	10.02	13.37	...	...	...	...	14.98	20.87	...	44.53	5
July	9.00	17.25	...	...	...	...	16.92	26.00	...	61.00	5
Aug.	11.00	17.00	...	...	...	...	19.00	26.00	...	51.00	5
Sept.	21.09	14.16	...	...	...	...	21.58	26.50	...	44.54	5
Oct.	11.00	14.50	...	...	...	...	4.25	20.30	...	53.22	5
Nov.	12.06	6.50	...	...	...	...	...	15.19	...	48.00	6
Dec.	...	...	...	...	...	...	...	12.38	...	17.19	8

* Brown Bast trees still yielding latex.

280.24 Total yield in January.

PART V.

BROWN BAST EXPERIMENTS ON GOOD AND POOR YIELDERS.

The most important feature regarding Brown Bast is the possibility of the affection acting as a limiting factor when high yields are in question. Much attention has been directed towards increasing the yielding capacities of individual trees, over the last two years, by means of seed selection and vegetative propagation. Yields of 1000–2000 lbs. per acre have been suggested as possible from "bud-grafts" developed from high yielding stock.

Little evidence had been brought forward at the time to show that high yielding trees were more susceptible to Brown Bast than trees which give less latex per tapping, though running through most of the literature was the suggestion that high yielders were more susceptible than low yielders. Keuchenius (f) has since dealt with this problem and on his results states that "the belief i e., that good yielders are more susceptible to Brown Bast, is to be relegated to the realms of myth". The terms susceptibility and immunity have been used very loosely in connection with the Brown Bast problem. *A priori*, if Brown Bast is an exhaustion phenomenon high yielders will tend to develop the affection more quickly than trees yielding less latex, under the same conditions; at the same time it cannot be claimed that poor yielding trees show a superior degree of immunity, as will be shown decisively below.

TABLE No. 8(*a*).

Yields from Poor Yielders.

Tree No.	Yield in Liq. Ozs.	Jan. 1922	Feb.	Mar.	April.	May.	June.
1	½	9.82	15.95	16.03	9.08	15.23	13.27
2	½	10.87	7.04	10.77	4.84	6.85	6.82
3	¼	8.82	8.72	6.47	1.51	6.06	3.74
4	¼	11.62	5.30	3.39	3.43	6 43	2.86
5	¼	7.82	7.91	6.95	5.69	6.95	5.29
6*	½	18.02	12.29	9.26	11.43	15.24	13.33
7*	½	16.85	16.91	14.98	5.82	4.11	...
8	½	10.51	12.51	12.31	7.74	8.77	6.94
9	½	13.57	6.51	4.84	4.16	5.58	3.86
10	½	11.49	11.89	11.16	7.72	6.82	6.62
11*	½	15.62	11.36	8.98	6.58	7.26	15.85
12*	½	15.94	12.08	4.26	4.66	4.07	...
13	¼	13.41	9.60	7.88	3.98	4.24	...
14	¼	11.46	7.42	4.88	3.63	9.36	9.61
15	½	12.85	7.95	11.00	7.74	10.98	13.36
16	½	12.63	20.91	13.50	11.35	15.19	12.89
17	¼	10.85	9.08	6.60	5.94	7.31	6.62
18*	¼	16.09	13.34	13 44	15.01	15.22	15.89
19	¼	13.04	7.25	6.15	8.84	11.16	9.26
20*	½	15.82	6.04	7.06	9.08	8.22	9.59
21	½	13.46	12.85	4.07	2.00	6.05	...
22	½	11.52	11.19	4.69	4.32	6.26	2.94
23*	½	16.71	8.65	9.67	9.10	9.14	8.25
24*	½	16.76	29.13	20.60	17.35	16.75	17.19
25*	¼	15.60	6.90	7.24	5.92	4.00	4.95
			none	none	none	none	7*
							12*
							13
							21
	Totals ...		...	...	...	...	2 + 2

* Trees with over 15 ozs. of Rubber in January's tapping.

TABLE No. 8(*a*)—(*contd.*)

Yields from Poor Yielders.

Tree No.	Yield in Liq. Ozs.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	½	15.00	16.09	16.13	16.38	11.50	7.00
2	½	7.01	7.17	10.61	...	...	...
3	¼	6.00	6.44	10.33	9.19	8.50	8.00†
4	¼	5.00	3.11	...	...	...	...
5	¼	6.38	5.25	9.09	7.20	7.31	6.75
6	½	15.06	13.31	15.61	14.25	12.00	16.25
7	½	...	...	...	...	...	...
8	½	7.17	7.17	7.91	10.31	8.50	4.00†
9	½	6.00	8.11	5.64	9.38	4.00	...
10	½	8.63	3.31	...	...	...	...
11	½	12.00	12.13	3.67	...	...	...
12	½	...	...	...	...	...	...
13	¼	...	...	...	...	...	...
14	¼	11.00	3.28	...	...	...	...
15	½	17.28	16.02	15.35	18.63	19.06	20.00
16	½	20.00	17.28	16.35	20.06	16.38	7.00†
17	¼	11.00	8.44	12.28	...	...	...
18	¼	15.00	14.13	16.35	23.94	15.41	8.19†
19	¼	11.00	10.06	12.41	12.43	13.06	9.00
20	½	9.00	8.62	10.53	12.38	9.00	7.50†
21	½	...	...	...	...	...	...
22	½	7.00	5.62	9.25	9.00	9.50	8.25†
23	½	11.00	10.31	11.35	15.13	8.00	6.94†
24	½	16.00	20.16	16.31	...	...	...
25	¼	9.98	12.13	14.19	9.06	17.03	12.50†
		no increase	no increase	4 10 14	2 11* 17 24*	9	25* 18* 8 16 23* 20* 3 22
Total ...		...	...	3	2 + 2	1	4 + 4

* Trees with over 15 ozs. of Rubber in January's tapping.
† Brown Bast trees in December.

TABLE No. 8(*b*).

Yields from Good Yielders.

Nos.	Amount of latex in cup.	Jan. 1922	Feb.	Mar.	April	May	June
	Liq. Ozs.						
1	2¾	27.10	36.79	13.11	2.60	2.52	...
2	2	18.66	16.00	9.74	9.24	9.80	...
3*	2½	14.82	14.30	2.26	2.33	...	...
4*	5	15.50	10.22	2.97	8.26	26.39	9.93
5*	2	10.33	9.86	12.06	9.87	12.90	11.85
6	3½	24.90	28.80	27.05	18.98	23.95	22.46
7	2¼	22.28	27.95	3.29	2.57	6.71	...
8*	2	13.71	23.82	4.74	2.00	5.16	...
9	2	25.85	40.60	15.26	2.21	7.21	...
10	2¼	19.27	31.90	35.32	26.67	25.72	35.16
11	3	22.72	11.55	32.59	21.45	23.85	27.46
12*	3	13.07	24.77	28.50	16.82	15.83	20.10
13*	5½	13.54	13.21	11.70	8.93	17.34	7.08
14*	2¼	11.18	22.04	21.82	15.12	13.66	11.91
15*	3¼	12.81	20.86	20.58	15.17	19.61	19.86
16	2¾	17.07	32.99	36.30	28.73	28.45	24.71
17*	2	13.09	40.74	40.78	19.14	15.90	...
18	3¼	24.53	36.39	34.17	25.27	28.95	34.43
19	2⅓	22.00	13.38	19.33	12.86	22.86	17.14
20	2	25.39	42.44	19.77	42.20	47.57	60.20
21	2¾	20.79	17.24	22.50	16.51	17.72	18.60
22	3½	16.87	30.31	32.75	32.07	30.35	30.79
23	5½	17.06	15.72	16.62	17.37	17.19	...
24	3¼	20.98	23.25	23.77	18.08	29.35	24.74
25	2¼	21.92	18.35	8.16	4.00	...	...
			none	25 3*	none	2 7 8* 17* 9 23	4 1* 13* 19
	Totals ...		...	1 + 1	...	4 + 2	2 + 2

* Trees with less than 16 ozs. of Rubber in January's tapping.

TABLE No. 8(*b*)—(*contd.*)

Yields from Good Yielders.

Nos.	Amount of latex in cup.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Liq. Ozs.						
1	2¾	...	...	...	...	...	...
2	2	...	...	...	...	...	...
3	2½	...	...	...	...	...	...
4	5	..	...	...	...	...	...
5	2	13.84	13.00	10.26	17.00	7.19	...
6	3½	22.56	28.00	25.23	28.00	30.02	12.31
7	2¼	...	...	...	...	...	...
8	2	...	...	...	...	..	...
9	2	...	...	...	...	...	...
10	2¼	32.00	39.00	39.89	42.00	40.00	17.00†
11	3	23.95	26.00	32.12	27.00	28.05	33.25
12	3	33.12	31.00	33.12	22.00	36.00	40.13†
13	5½	...	...	...	...	...	...
14	2¼	12.00	17.00	...	...	...	...
15	3¼	22.00	19.03	24.41	...	...	...
16	2¾	31.00	30.03	46.41	25.00	28.19	9.19†
17	2	...	...	...	...	...	...
18	3¼	35.00	25.03	23.01	...	...	...
19	2½	...	...	...	...	...	...
20	2	80.00	61.03	25.03	...	..	...
21	2¾	19.00	23.00	19.25	26.00	24.00	25.25†
22	3½	34.00	28.00	31.12	32.00	29.50	28.00
23	5½	...	...	...	...	...	...
24	3¼	20.38	31.12	26.31	24.00	27.00	23.75†
25	2¼	...	...	...	...	...	...
		no increase	14*	15* 18 20	no increase	5*	10 16 24 21 12
Totals ...		...	+1	2+1	...	1	5

* Trees with less than 16 ozs. of Rubber in January's tapping.

† Brown Bast trees in December.

The results of the following experiments will give some indication as to possibilities. Twenty five good yielders and twenty five poor yielders were selected from a block of 10 years old trees. The tapping system in operation was a single cut, daily, on $\frac{1}{4}$ of the circumference. The trees were selected on the result of a single days tapping by measuring the yield of latex in a graduated cylinder. The trees were divided as under.

Good Yielders	...	2 ozs of latex and above.
Poor Yielders	...	$\frac{1}{2}$ „ „ „ „ below.

The trees were put under a Full Spiral cut immediately and at the end of the first month the yields were checked in order to see which trees could be regarded as consistent good yielders or poor yielders. The trees fell into the following groups:—

16 Good Yielders gave	...	16 ozs of Dry Rubber or over
16 Poor „ „	...	15 „ „ „ „ „ less

9 of the provisionally selected good yielders gave less than 16 ozs of Dry Rubber and 9 of the poor yielders gave 15 ozs of Dry Rubber or over. That the method of selection may be considered satisfactory for our particular purpose is shown by the great majority of poor yielders remaining poor yielders over the experimental period.

Thus there is one class of definitely good and one of definitely poor yielders. The results are given in concise form below.

	Good Yielders. (Total No. of B. Bast cases)	Poor Yielders. (Total No. of B. Bast cases)
March	2	0
April	2	0
May	8	0
June	12	4
July	12	4
August	13	4
September	16	7
October	16	11
November	17	12
December	22	20

This analysis shows some interesting pointers. The first is relative to the assertion that high yielding trees are susceptible to Brown Bast which implies that some trees, presumably poor yielders, are immune to some extent. This conception must be considerably modified on the above results though the reason for the statement becomes plain. The high yielding trees taken as a whole, develop the affection more rapidly than a similar number of low yielders, but low yielding trees are still susceptible. It will be shown later that taking the twenty-five trees which were originally included in the group of Poor Yielders, the comparatively high yielders in this group developed

Brown Bast much less rapidly than the extreme poor yielders. The difference in time-periods will be much exaggerated with a light routine tapping system, and the true state of affairs is not likely to be exposed except under heavy tapping conditions. The susceptibility of high yielding trees is more apparent than real. Though further experiments of this type are desirable, the evidence seems so clear cut that we are warranted in suggesting that the use of the terms susceptibility and immunity, as applied to Brown Bast, should be discouraged, as such use only leads to misconceptions. Our results on these lines agree in the main wtth those of Keuchenius but we cannot go so far as to agree that the belief is purely mythical. Under routine conditions without exact control, the above conclusion regarding good yielders would undoubtedly seem valid.

Further, it will be noted that the exceedingly good yielders in the first selection, Nos. 4, 13, and 23 developed Brown Bast quickly. The high yield presumably was a preliminary indication to the early development of Brown Bast though none of the three trees showed high yields after the selection was made. As pointed out above, the appearance of Brown Bast under routine tapping would be retarded considerably, and under such conditions it is probable that such trees would continue to give high yields for a considerable period without showing signs of Brown Bast, and would be chosen as "mother trees" to start selection from. The danger is obvious and further comment superfluous.

In the next group of high yielders to be considered, seven trees with 3—4 ozs of latex in the preliminary measurement, are included. Five of these Nos. 6, 11, 12, 22 and 24 did not develop Brown Bast until December, but Nos. 6 and 12 were giving indications that Brown Bast was imminent by big variations in yield. No. 12 fell in the middle class yielding less than 16 ozs of Rubber during the first month's tapping. The striking feature in good yielding trees remaining free from Brown Bast over a long period of heavy tapping, is the steady yield over the experimental period.

If the results from the plot of poor yielders are analysed, a certain group of trees, Nos. 1, 6, 15, 16, 18, 24, will be noted as giving yields consistently higher than the remainder. All of these trees with the exception of No. 24, went through the experimental period, without developing Brown Bast. Thus had we been dealing with this plot alone, the statement could have been made that comparatively good yielders were less susceptible than poorer yielders.

The terms, susceptibiliiy and immunity, cannot be used happily in the light of the above results. Both plots show that the comparatively high yielders may resist the onset of Brown Bast to a higher degree than trees which are yielding less latex. These facts show the danger of accepting generalisations based on comparative counts taken over large areas without the necessary experimental control.

The inference would appear to be justified that all trees yielding high above the average are likely to suffer from Brown Bast and

that trees yielding far below the average show a tendency in the same direction. It is quite possible that these two features may be connected, that the low yielding trees may have been high yielders some time previously and their low yielding may be the indication of an approaching attack of Brown Bast. The steady, average yielding trees seem eminently the most desirable and the least likely to suffer from this affection.

Much has been written regarding selection of "Mother trees," from which to obtain "Bud-Wood" for the purposes of grafting. Selection has been based on yields under routine tapping, combined with counting the number of latex rings. In the writers' opinion, little reliance can be placed on the counting of latex rings, as the exceptions to any rule are numerous, and many curious results are obtained. It is doubtful if yields under routine tapping have been continued long enough in any single case to form a satisfactory basis for selection. The table for good yielders indicates the possibility that if selection for yield and Brown Bast resistance is carried out as in our experiments the trees select themselves by their definite behaviour. Nos. 6, 11, 12, 22 and 24 are distinct in both respects, and only one single tree No. 20, could be taken into comparison. This tree gave large fluctuating yields over a 9 months period giving a total of 403.63 ozs. The Brown Bast resistant, steady yielders gave a total for 12 months of between 220—355 ozs., and their resistance to the onset of Brown Bast should be a strong argument for their selection as Mother trees. The suggestion may be made that experimental work of this type might result in finding the most suitable "mother trees" for selection purposes. On the basis of selection as practised up-to-date, our results lead us to think that "daughter trees" will vary in many directions and that it will be difficult to establish correlations. This seems to be supported by the latest reports from Java.

Summary of Important Features.

It will be convenient to summarise at this point the more important features noted in the preceding parts.

Part 1.

(*a*) The sudden increase in number of Brown Bast cases during certain months of the year was noticed.

(*b*) The relation between yield and amount of bark removed as observed under routine tapping systems, i.e. $\frac{1}{4}$ Spiral and $\frac{1}{2}$ Spiral, breaks down when a heavy tapping system, i.e. Full Spiral, is in operation. Heavy tapping and high yielding probably may be regarded as equivalent terms.

(*c*) Suggested that under experimental conditions, it is doubtful if significant comparative results with reference to Brown Bast, can be obtained under routine tapping.

(*d*) Daily tapping compares unfavourably with Alternate Daily or any tapping system with longer intervals between successive tappings.

Part 2.

(*a*) Sudden rise and quiescent periods noted in Part 1, confirmed. Sudden increase in number of Brown Bast cases suggests "trigger action."

(*b*) Stoppage of Brown Bast extension at old "opening-up" marks in large percentage of cases noteworthy. Similarly noted that in large percentage of cases Brown Bast does not extend much below the tapping cut if spotted in the earliest stages but in 14% of Brown Bast cases the affection spreads to the base of the tree after heavy tapping in spite of resting.

(*c*) Heavily tapped, abnormal plot showed no Brown Bast over an eleven months tapping period. Sudden increase in average monthly yield is related to sudden increase in percentage number of Brown Bast cases. Continued tapping over a lengthy period with a control plot, showed a permanent increased yield and normal Brown Bast development.

(*d*) No definite connection between rainfall and Brown Bast development.

(*e*) Heavy Brown Bast periods coincide with dry periods if yield continues high during the dry period.

Part 3.

(*a*) Various features under Part 1 and 2 confirmed.

(*b*) Noted in this series that a sudden increase or decrease in yield was a fairly certain indication of an early attack of Brown Bast.

(*c*) A plot, heavily tapped during the heat of the day, showed small diminution in yield, as compared with other heavily tapped plots, tapped early. Estate practice leads to the conclusion that late tapping results in considerably decreased yields. This feature is of interest because of the Part 1, observations, where it was shown that the usual relationships observed under light tapping, break down when heavy tapping is taken up.

(*d*) Shown that wide depressions of recently renewed bark will prevent Brown Bast extension successfully, functioning in a similar manner as narrow deep cuts to the wood, as demonstrated by Keuchenius in Sumatra. Numerous dry trees developed in the two plots with isolation cuts without showing Brown Bast symptoms.

(*e*) Circumstantial evidence obtained to indicate that wounding influence is of small importance.

(*f*) Explanation offered of presumed non-occurrence of Brown Bast in early days of rubber plantations, when excessive tapping and yields were the order of the day.

Part 4.

(*a*) Shown that trees having suffered from Brown Bast are more readily readily attacked than trees not previously affected.

(*b*) Evidence obtained which provides substantial grounds for stating that Rands endeavours to obtain immune trees on the basis of short periods of heavy tapping are not likely to prove successful.

Part 5.

(*a*) Shown that high yielding trees develop Brown Bast more readily than low yielding trees, but the latter are not immune to Brown Bast. Over a long period of heavy tapping, low yielders finally develop Brown Bast, in some cases earlier than better yielding trees.

(*b*) Very high yielders develop Brown Bast very quickly.

(*c*) Important point indicated that if yield remains constant, without large variations, over the experimental period, good yielding trees remain free from Brown Bast, even under heavy tapping.

THEORETICAL CONSIDERATIONS.

The experimental data obtained in the preceding portions strongly support the view of a disease of "physiological" origin. Keuchenius (6) is the only strong backer of a "bacterial" as opposed to a physiological origin of Brown Bast. He strongly criticises the work of other investigators in presenting his own views of a probable bacterial origin of Brown Bast.

In support of this view, Keuchenius attaches weight to isolation experiments, when under the same conditions, he obtained Bacteria from bark affected with Brown Bast but not from healthy. His final inoculations were unsuccessful and the only just conclusion to be drawn was that if Bacteria are the cause of Brown Bast, he had not succeeded in isolating the causative agent. He suggests possible explanations why the inoculations proved unsuccessful, but these are unsatisfactory in view of his own statements, apart from the negative results obtained. He says (6) "If now a bark area is tapped which is connected with the affected area, latex flows from the diseased tissues to the tapping area and there is every risk that a few Bacteria are passively carried along from the border of the affected area by the latex and so cause the spread of the disease." Judging from this it appears to us that it would only be a matter of time and trouble for Keuchenius to have obtained successful inoculation results if his views are truthfully reflected by the above statement.

To quote again (6) "the negative results of the infections experiments with diseased bark and bacterial cultures is no more a disproof of the infections theory than it is an argument in favour of a physiological cause." We fail to realise the cogency of this argument, but this fact is certain, that a "bacterial" cause cannot be admitted

in the absence of positive inoculation results. All other investigators and Keuchenius himself admit the failure of innumerable attempts in this direction i.e. to show that the disease can be transmitted from diseased to healthy trees, and no side issues can be of assistance in the absence of such fundamental data. It appears to us that Keuchenius refuses to accept the only justifiable conclusions which can be reached when the whole of the Brown Bast work is taken into consideration.

Belgrave spent considerable time in repeating the isolation experiments of Keuchenius in the F.M.S. His early results were successful, but further work led him to the conclusion that Bacteria could not be isolated from Brown Bast tissue if sufficient care was taken to maintain sterility during the initial operations. This conclusion does not influence the results of Keuchenius along this line because the latter's controls with healthy bark remained sterile.

Keuchenius suggests that these Bacteria probably inhabit the latex vessels in small numbers, but no other elements of the cortical tissues are invaded. During the spread of the disease the Bacteria can only pass along the latex vessels. To support this, he instances the results of isolation cuts used for limiting the area of spread of the affection on individual trees. He also states that resting or discontinuance of tapping affects restriction of the disease to the infected area. He says (6) " This latter is easily understandable, as spread of the disease in a chronic stage can only occur when healthy latex vessels, which are in contact with diseased, are opened, so that latex flows therefrom." This statement cannot be held in its entirety in face of the careful checking in our experimental plots, which showed that 14 per cent of Brown Bast cases artifically developed on the cut continued to spread to the base of the tree after tapping was stopped.

With reference to the importance of isolation cuts in the theoretical consideration of the cause and the presence of Bacteria in the latex vessels he says :—" This shows that healthy and diseased parts of a bark layer cannot be connected again if they have been separated by an isolation cut, and that in consequence no further spread can occur." This statement refers not only to deep isolation cuts made to the wood, but also to cuts which do not reach the cambium, but go deeper than the infected layers. On Part 3 experiments show that this statement does not meet the case for the affection travels easily over a narrow isolation depressiou of $\frac{1}{2}$ an inch at ordinary tapping depth and occasionally across a wide depression of $1\frac{1}{2}$ inches.

There seems little support remaining to enable Kechenius to maintain his " bacterial " theory. We have now to deal with the arguments he arrays against the acceptance of a " physiological " theory, but it will be advisable to consider various points relating to the physiology of *Hevea brasiliensis* before doing so.

It is usually assumed that the physiological functions of *Hevea brasiliensis* proceed on normal lines ; all analogies respecting physiological function are based on this normality of the rubber tree. Ringing experiments carried out by this Department, show conclusively

that ringing by excision of cortical tissues, sufficient to ensure total interruption of elaborated food materials from above downwards through the bast elements, does not result in the death of the tree. Trees ringed in 1917 were still alive in 1921 since when the gap in the cortical tissues has been bridged and the trees are now carrying on normally. This feature has been reported from Uganda also. Further, experiments have been conducted by Belgrave with trees tapped over the whole circumference (Double V) at varying intervals and careful microscopic examination does not reveal any abnormality. There seems to be no undue interference with important food currents, although the circumferential tapping probably results in the cutting of healthy sieve tubes, outside the innermost cortical layers which are not excised during tapping.

The deduction to be made is that the sieve tube elements in the cortical tissues of *Hevea brasiliensis* are not of the same importance for food transport as in other plants, or that there is an alternative route for transport of elaborated food materials under abnormal conditions (i.e. when tapping). Dixon and Ball (3) have drawn attention to a similar possibility in plants with large underground storage organs, such as the potato, and have expressed the opinion that diffusion in the bast is inadequate to account for the observed rate of transport of carbohydrates in plants. Thus *Hevea brasiliensis* under plantation conditions, is probably one of a class of plants which must be considered physiologically abnormal, when compared with the majority of plants.

There is support for the above remarks. We have demonstrated that "Phloem Necrosis" or lignification of the sieve tubes is a common feature in the cortex of *healthy* rubber trees which are being tapped. "Phloem Necrosis" is a special feature of certain diseases of plants, the best known being that demonstrated in the potato by Quanjer (9). *These diseases can be easily transmitted from an infected to a healthy plant.* Farmer and Horne (4), suggested that Brown Bast was a type of "Phloem Necrosis," but we dissent from this view as we have plots of *healthy* trees under comparative experiment which were separated and are being compared according as to whether they showed "Phloem Necrosis" or not. The possibility may be suggested that non-functional sieve tubes become lignified. These facts are strong evidence for suggesting that the ordinary functions of *Hevea brasiliensis* should be considered as deviating from the normal, and experimental evidence obtained should be considered from this standpoint.

Further, the latex vessels of *Hevea brasiliensis* when tapping is in full swing, must be considered of great importance when discussing physiological problems of *Hevea brasiliensis.* The latex vessels of this plant contain substances of high osmotic activity, and when the water balance is disturbed as during tapping, (latex contains about 60% of water by volume under routine tapping conditions) the latex vessels must exert a strong water drawing influence upon the surrounding cortical tissues, in order to replace that which is lost. It is not difficult to visualise that loss of water as a result of excessive extraction of latex would bring about a critical stage, when the usual

physiological relations would break down and bye-products would accumulate in the cortical tissues within the sphere of influence to be reflected as Brown Bast symptoms.

The working hypothesis based on the theory of "physiological" origin was the probable importance of the tapping operation. A fair amount of general work had indicated the fact that high yielding trees often became affected with Brown Bast and therefore the possibility that excessive yielding was the prime factor in the inception of this disease. Little controlled experimental work had been done to separate the two important factors in the tapping operation :—

(*a*) The influence of wounding owing to the cutting by the knife.

(*b*) The influence of excessive withdrawal of latex.

It is unnecessary, at this point, to repeat the various features of importance observed during our long term experiments which directly support the view that withdrawal of excessive amounts of latex are of first importance, while wounding during the tapping operation plays little, if any part.

Accepting a "physiological" explanation we have to attempt to find a satisfactory explanation for the abnormal conditions which initiate Brown Bast symptoms When considering excessive yielding as the prime factor, there are two possibilities :—

(*a*) The importance of the solid constituents of the latex.

(*b*) The importance of the liquid constituents of the latex.

Many writers have suggested that if excessive yielding is a factor of importance, exhaustion would follow as a result of loss of elaborated food materials supplied by the leaves. We have indicated above why this feature is probably of less importance than might be expected but there are two further points which prevent the acceptance of this view. Our knowledge of the loss of food materials by extraction of latex is based on coagulation results, comparing total solids after coagulation as against total liquid. Regarding cacaochouc content Belgrave found that if equal quantities of Brown Bast and healthy bark are extracted as thoroughly as possible with petrol, no significant differences can be obtained ; in some cases more rubber was extracted from Brown Bast than from healthy bark. Therefore as far as cacaochouc content is concerned there is no difference in amount of elaborated food materials stored in Brown Bast and healthy bark.

The second point is that in excessive yielding the percentage weight of coaguable content is always low or remains low for considerable periods of time, as compared with percentage cacaochouc content extracted under a light tapping system, which means that the percentage volume of water is comparatively higher. We have pointed out above the importance of the water drawing capacity of the latex vessels upon the surrounding cortical tissues and under heavy tapping conditions it is not difficult to realise the importance of this influence

when we consider the increased supplies of water demanded from the cortical tissues, not only because of the increase in quantity of latex extracted, but because of the large increase in percentage volume of water in the extracted latex. We consider this abnormal strain, placed upon the water transmitting mechanism in the cortical tissues, when excessive latex extraction is in operation, as the primary reason for the appearance of Brown Bast symptoms.

We can now consider the points which Keuchenius argues are not sufficiently explained by a "physiological" theory. He constantly refers to the failure to increase the number of Brown Bast trees in experiments of tapping to exhaustion. In view of the work detailed in the preceding parts it would be difficult to discuss the position, but we have further experiments in hand which suggest that Keuchenius may have some reason for his statement though the experiments with which he supports his view are far from satisfactory (Vide Part 11). It is impossible to form a correct judgment from single plots, tapped over a short experimental period of 30 days. Our Part 11 experiments show one plot which remained free from Brown Bast for 11 months under heavy tapping and we have other single plots now under experiment which are behaving similarly. These latter are on a better mechanical type of soil, and their behaviour brings support towards our view of the water relationships being of primary importance in the Brown Bast problem. The exhaustion experiments carried out by Keuchenius and other investigators were of short duration and the experimental methods too exhaustive and gave the trees no chance of imitating the growth conditions under which Brown Bast appears normally.

Keuchenius points out that "interruptions of metabolic assimi-
"lation provide an impossible explanation, because the worst
"interruption and simultaneously the severest exhaustion would be
"expected in the wintering season, when the yields of the trees decrease
"and reserves are consumed by the formation of new leaf. The facts
"however prove that during this period which coincides with the dry
"season the disease percentage falls." This directly supports our views; by the reduction in yield the trees are afforded some measure of protection against Brown Bast attacks and so a fall in the disease percentage might be expected. The wounding influence during the wintering period remains the same, further evidence to support our view that in the problem of Brown Bast as related to routine tapping, the wounding influence is of small significance, if any.

He says further "Another fact of importance which cannot be
"explained by the physiologists, namely the Metastase. Physiological
"theories, whether based on exhaustion, wound reaction or metabolic
"interruptions may explain that Brown Bast will not spread
"when the tree is rested (our results show that under certain condi-
"tions, in a fair percentage of cases Brown Bast spreads even if the
"tree is rested), but it remains inexplicable that the spreading may be
"prevented by isolation of the affected area, though the tapping is
"continued outside thereof. For if exhaustion, wound reaction or
"interruptions of nutrition were the cause, the cutting of isolation
"channels would further aggravate the supposed causes and the

" disease would reappear immediately (sic.) on a new tapping surface. " *That however, does not happen* which proves that the physiological " theory fails in many respects." With reference to the cutting of isolation channels aggravating the cause, increased wounding will have little effect, according to our evidence. Interruptions of nutrition are probably of little importance as respects the transport of elaborated food materials for reasons given above. The third objection that exhaustion does not account for the peculiarities observed depends largely on what is meant by exhaustion. Accepting our explanation of the water relations being of primary importance, this objection cannot be upheld. We have, at least, shown that previously Brown Basted trees develop the affection more rapidly than normal trees, so that even if the reappearance of Brown Bast on a new tapping surface after being isolated by deep cuts is not so immediate as to satisfy Keuchenius's demands, they still retain their capacity for an early appearance of Brown Bast. Further to our views, the water relationships in the cortical tissues are purely local and any degeneration would be progressive, one individual cell affecting its nearest neighbours just as the water transfer is from cell to cell according to the osmotic balance. Therefore there is no reason to expect that Brown Bast will reappear immediately on a fresh tapping surface after an affected panel has been treated by an isolation cut. Local progressive degeneration would certainly be prevented by isolation cuts made in healthy tissue below the diseased area. Moreover, rapid or slow spread would depend largely on the individuality of the tree.

Most of his arguments run on the same lines and seem to be based on general observations which have been obtained by various investigators over large areas or on experimental plots which have not satisfied the requisite conditions. Many of our results are in line with those of Keuchenius and had he accepted the negative results of his own inoculation experiments probably he would have seen the explanation which satisfies most of the information obtained. There is only one other matter to which he attaches importance and to which we offer objection. He strongly emphasises the results he obtained by putting horizontal tapping cuts on 76 trees and then covering the cuts thoroughly on alternate trees with thick strips of cotton wool soaked either with a 0.1% solution of Mercuric Chloride or with dirty ditchwater. In 30 days 8 out of 37 trees with the cuts covered with the ditchwater soaked cotton wool had Brown Bast while only 2 of the 37 trees with the disinfected cuts showed Brown Bast. He considers that this experiment strongly supports the infection theory and also explains the influence of light and moisture. Apart from the two disinfected trees getting Brown Bast, all our experiments show that such differences are to be expected in individual plots, and it was because of differences of similar magnitude that in all tapping experiments a three monthly period of preliminary experimental heavy tapping with all the plots to be compared was considered absolutely necessary before any conclusions could be drawn from the final results. In any case such experiments seem to be leading a long distance away from the important point in this problem, which is the development of this affection under ordinary tapping conditions.

Sanderson and Sutcliffe (13) in an appendix referring specially to "Dry Trees" emphasise the importance of the latex vessels in the water economy of the cortical tissues. Their explanation for the phenomenon of "Dry Trees" is practically on the same lines as the one we offer for the appearance of Brown Bast symtoms. They apparently regard "Dry Trees" and "Brown Bast" trees as representing two distinct classes of phenomena and say "A tree may quickly recover from temporary dryness by resting, if Brown Bast is not present; when the dry condition, either partially or wholly, is due to Brown Bast, no such recovery results by resting."

Our results are in complete accord with those of Keuchenius (6) on this point and show that in the great majority of cases, if Brown Bast is spotted early, resting for a month is sufficient to enable the tree to recover, but if tapping is continued and as a result, the affected portion allowed to increase until a large area is involved, a progressive series of phenomena follow, the end result of the series being the formation of "Burrs." "Dry Trees" may be regarded, in our opinion, as a half-way stage; the trees go "dry" and this refusal to yield affords them a measure of self-protection against the approaching symtoms of Brown Bast. The behaviour of Plot A and Plot G in our Part III experiments, in which comparatively large numbers of "Dry Trees" appeared without definite Brown Bast symptoms, supports this view. The bark areas being tapped above isolation cuts begin to give latex yields which decrease rapidly as the tapping cut comes within two inches of the isolation cut, most probably owing to the failure of water which should have been supplied to the latex vessels by the adjacent cortical tissues. A similar explanation satisfies for the number of "Dry Trees" which usually appear during the wintering season.

Thus if the observations of Keuchenius and our own regarding the efficacy of resting trees suffering from slight attacks of undoubted Brown Bast are accepted it will be seen that Sanderson and Sutcliffe's view agrees with that presented in this paper; at least no hard and fast line can be drawn to separate Brown Bast trees and "Dry Trees" on the basis they adopt.

A 'physiological' theory is the only one which covers the experimental observations. We have observed a direct correlation between increase in yield and increase in percentage number of Brown Bast cases and shown further that Brown Bast may increase during dry periods, so that the influences of Rainfall and Moisture are not of supreme importance. In all our heavy tapping experiments on Castleton the differences were sufficiently large to prove the statement that the number of Brown Bast cases under heavy tapping or excessive yielding increases out of all proportion to the extra amount of dry rubber obtained. This in itself indicates that the water content of the latex is of more significance in the initiation of Brown Bast symptoms than the dry rubber content.

A strong argument comes up in our Part 5 results, where we showed that "Bad yielders may develop Brown Bast more readily than comparatively good yielders", and that the significant feature of

trees remaining free from Brown Bast under heavy tapping was the steady, non-fluctuating yield over the experimental period. The steady yield, high or low, indicates a balanced condition for the physiological activities of the tree and as long as the balance is maintained, there appears to be no excessive strain. As the junior author noted in the field, a sudden increase or decrease in the yield was a practically sure indication that a Brown Bast attack was imminent.

Fluctuations in yield mean considerable interference with a balanced condition in the water transmitting tissues associated with the supply to the latex vessels and this may bring about an abnormal condition which finally leads to the production of bye-products not usually associated with the healthy activities of the cortical tissues.

The sudden rise in percentage number of Brown Bast cases is difficult to explain and no suggestions can be made without further confirmatory experiments. It might be mentioned that these field experiments were under the supervision of three different officers during the four years experimental period and all reported the same phenomenon.

Recent work on phytopathological problems has brought into prominence the importance of a stable water balance if a healthy condition is to be maintained. Recently Mason (7) working on 'Die-Back' of Limes in Montserrat, a very serious disease, cautiously concluded that rapid and repeated fluctuations in the water supply of the growing tissues is at least as important a factor as any other in causing 'Die-Back of Limes.' A similar explanation has been suggested for shedding of Cotton Bolls in the West Indies. It is becoming recognised more and more, that important as insect pests and fungus diseases are, the physiological condition of the host plant is often the first factor in the incidence of the disease.

A cautious attitude regarding the interpretation of the data obtained in our experimental work must be maintained but we feel some confidence in so far as the evidence obtained by Keuchenius runs on much the same lines as that contained in the present investigation. So far only the fringe of this complicated subject has been touched and for a complete explanation team work is a necessity. A close examination of soil conditions, correlated with experimental tapping and histological work would undoubtedly give much invaluable information, but pressure of other work prevents us carrying on except in regard to small details.

Investigations in Relation to Planting Policy.

The period covered by the experiments has been noteworthy because of the attention given to the possibilities of increasing individual yields by seed selection and bud-grafting. As bud-grafting has been shown to be easy and successful of operation this method has been mostly used and in cases on a large scale.

The production of high-yielding trees by artificial breeding joins issue with the probability of high yielding being the prime factor in

the cause of Brown Bast. This brings up the vital question of disease probabilities in future generations of trees which have a definitely higher yielding capacity than the parent trees.

We do not intend to deal fully with the disease aspect in relation to future production in high yielding trees: this has been done in a previous article (13). A brief sketch may be given here.

Higher yielding trees will have physiological activities of a different order than present day trees so that present day behaviour gives us a doubtful guiding line. This may be pointed in many cases by the results obtained in our tapping experiments, if we assume that the high yields obtained by heavy tapping under present day conditions will be equivalent to the possibly higher yields to be obtained under a lighter system in the plantations developed by vegetative reproduction. Part I shows that the usual relationships observed under light tapping systems does not hold for a heavy tapping system; Part III shows an experiment indicating a similar feature when tapping at mid-day showed very little decrease compared with similar tapping early in the day. With reference to Brown Bast experiments, under routine tapping, Keuchenius strongly emphasises the fact that resting the tree will result in the disappearance of the symptoms, whereas under heavy tapping, a fair percentage continued to spread, despite resting.

These facts indicate that it is doubtful if we can assume that objections to the policy of developing high yielding trees by vegetative selection will, with care in the future, be easily overcome. Such dogmatic statements are not helpful in the least. The facts are as follows:—

Rubber planting has been rendered unprofitable in British Guiana owing to the attacks of a leaf fungus. This species of fungus has not been recorded in the Middle East but close relatives exist.

Leaf-fall in Burma and Ceylon, caused by *Phytopthora Meadii*, causes large losses of crop. Up-to-date, leaf fall due to this cause is unknown in Malaya.

All phytopathologists are aware of the delicate balance of conditions which determine attacks by fungi. There are many cases of crops being attacked in one locality, and a locality near enough to be infected and growing the same crop, is free. There is no definite evidence on which to base any explanation in many cases, though in others such phenomena are definitely connected with early sowing, late flowering—the plants growing and producing their crop during periods unfavourable to the growth of the fungus.

This delicate adjustment of conditions can be well illustrated by Malayan experience. Black Stripe was considered a serious disease in 1910 in Ceylon and Java, but no evidence of this disease was found in Malaya until 1916. Now this disease regularly appears as epidemic in certain areas in Malaya where climatic conditions favour the development of the fungus. No adequate reason can be adduced for

the long immunity enjoyed by Malayan estates in respect of Black Stripe disease.

Again in 1916 Mouldy Rot made its appearance. No records of the causal fungus in Malaya (*Sphaeronema fimbriatum*) existed previously and though since recorded in Java, Ceylon and India remain free. The disease is becoming widespread throughout Malaya and although we have no definite evidence, the indications lead us to suspect a definite increase in virulence.

It is obvious that such abstruse matters can only be guarded against with the greatest difficulty and if similar phenomena which favoured a disease difficult of control were in evidence the chances are enormously in favour of the disease causing organism. It follows from the phytopathological point of view that all tendencies towards increasing the chances of fungi for attacking rubber trees should be strongly discouraged.

As we have indicated, conditions favourable or unfavourable for development of disease-causing organisms do not remain stable. It is quite possible that certain small changes in atmospheric conditions resulting from the opening up of large areas of rubber, with the consequent cutting down of jungle, have been primarily responsible for the appearance of Black Stripe and Mouldy Rot diseases. These small changes in atmospheric conditions are continually taking place and combined with any tendency towards progressive favoritism for fungal attacks, are decidedly to be guarded against.

There is little doubt that the policy of developing high-yielding trees will give a strong bias towards rendering the leaves of *Hevea brasiliensis* more liable to attack from fungi; to this should be coupled the fact that high yielding stands will contain a less number of trees per acre, so that losses of single trees could not be viewed with equanimity. Further, it is difficult to conceive of successful spraying operations owing to mechanical difficulties even if we disregard expense. These facts taken into consideration with the not too satisfactory records from Bud-grafted trees and the experimental evidence brought forth in this bulletin to show that yields and Brown Bast are definitely connected lead us to think we are justified in preaching caution and insisting that vegetative production of high-yielding trees is still in an experimental stage. The justification for this attitude is amplified by the extracts following this article, from recent lectures given by two of the leading scientists in Java, who have been investigating the possibilities of propagating higher-yielding trees.

Treatment.

This question need not be dealt with in detail here. Descriptions of methods so far practised i.e. light scraping and tarring, deep scraping and tarring, stripping, can be found in other publications (2) and (11).

Stripping has been favorably considered by some investigators and a complete and detailed account can be found in Sanderson and

Sutcliffe's recent work (13). This method is of considerable utility, when small portions of affected bark have to be removed.

Our investigations confirm those of Keuchenius and show that under present day conditions, if careful supervision is given and every effort made to spot Brown Bast as early as possible, in the majority of cases resting for a month is sufficient to arrest the spread of the disease. If an area of bark of any extent is involved, the affected area should be isolated by deep cuts to the wood. This method was tried early in 1918 by the Brown Bast Investigation Committee in Malaya, but it was reported that boring beetles attacked the tree through the dying patches of affected bark, and the method did not find favour. Evidently this objection has not proved a serious one in Sumatra, but it is probable that attacks of boring beetles might interfere with the success of this method in Malaya, when practised on a large scale. Up-to-date the senior writer has not observed boring beetles entering bark patches of Brown Bast affected tissue when isolated by deep cuts, but some previous work (15) indicates the possibility of this happening. There has been little opportunity to test this method over the last four years, since restricted yields have been the order of the day, so a definite opinion, for or against, cannot be given. However, we are of the opinion that deep isolation cuts will provide the most effective method, combined with economy, of preventing the extension of Brown Bast in affected trees.

Summary.

(1) Evidence obtained from prolonged tapping experiments is strongly in favour of the "Physiological" origin of Brown Bast.

(2) Evidence shows that over-extraction of latex is the most important factor in initiating Brown Bast; no definite correlations have been established as between other factors *i.e.* rainfall, etc.

The authors wish to acknowledge their indebtedness to Mr. W. Malcolm Miller who officiated as Assistant Mycologist for some months and did much recording work; to Mr. T. D. Marsh, who took charge of Castleton Estate when the junior author went on leave. We are specially indebted to Mr. W. N. C. Belgrave, Plant Physiologist, who not only aided the work by constant discussion and suggestions but placed the results of much unpublished work at our disposal.

(1) *Bobillioff, W.* - Over de oorzaak der bruine binnenbastziekte van *Hevea brasiliensis*. Arch. voor de Rubber Culture in Ned. Ind. 1920.

(2) *Brown Bast Investigation Committee* - The treatment of Hevea trees affected by Brown Bast. Commercial Press, Kuala Lumpur.

(3) *Dixon, H. H. and Ball, N. C.* - Transport of organic substances in plants.
Letter to Nature No. 2730, Vol. 109, Feb. 23rd, 1922.

(4) *Farmer, J. B. and Horne, A. S.* - "Phloem Necrosis" in Brown Bast Disease of *Hevea brasiliensis*.
Anns. of Botany, Vol. XXXV, No. CXXXIX, July, 1921.

(5) *Harmsen, J. R.* - Bruine Binnenbastziekte.
Batavia, (Ruygrok and Co.) 1919.

(6) *Keuchenius, P. E.* - Die Rindenbräune der *Hevea brasiliensis*, Eine Kritische Untersuchung.
Abdruck aus dem Centrallblatt fur Bact, Parasitenkunde and Infektions krankheiten, Zweite Abteilung: Bd. 55, 1921, Heft. 1/4.

(7) *Mason, T. C.* - Ligneous Zonation and Die-back in the Lime (Citrus medica var acida). Scien. Proc. of the Roy. Dublin Soc. Vol. M. (N.S.) P. 255—262, August, 1923.

(8) *Pratt, H. C.* - Brown Bast on rubber trees—its cause and spread.
Malayan Tin and Rubber Journal Vol. 6, 1917.

(9) *Quanjer, H. M.* - Mosaic disease of Solanacea and its relation to "Phloem Necrosis" and its effect on Potato culture.
Phytopathology, Vol. 10, No. 1, Jan,, 1920.

(10) *Rands, R. D.* - Bruine Binnenbast en tapproeven.
Ned. Ind. Rubb. Tijdsch. 1-6-1919.

(11) *Rands, R. D.* - Brown Bast Disease of Plantation Rubber. Its Cause and Prevention.
Archief voor de Rubber Culture in Nederlandsch India. 5c. Jaargang No. 5, Mei., 1921.

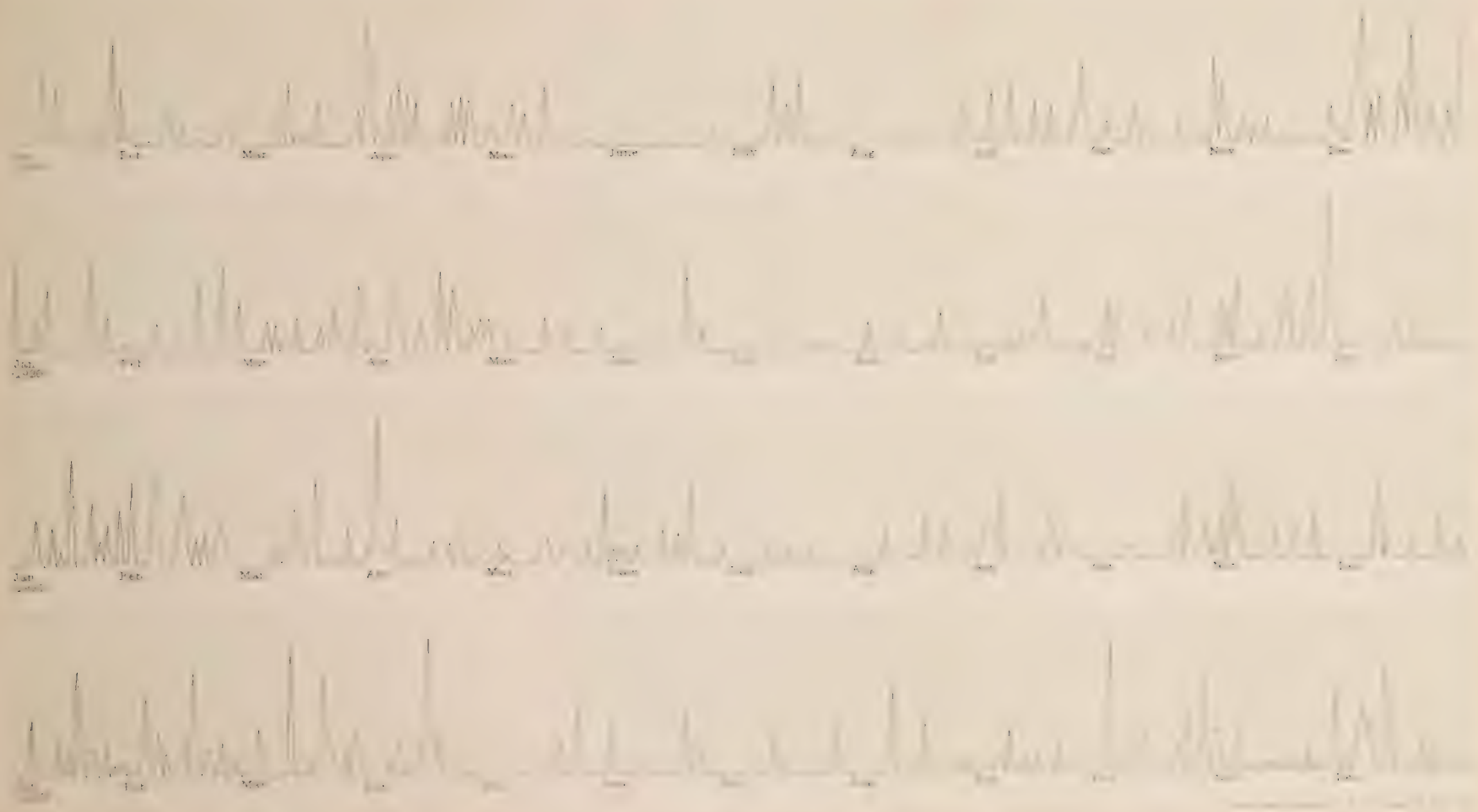
(12) *Rutgers, A. A. L. and Dammerman, K. W.* *Diseases of Hevea brasiliensis* in Java.
Med. Van. het Laboratorium Von Pflanzenziekten, No. 10, Page 27—33, 1914.

(13) *Sanderson, A. R. and Sutcliffe, H.* - Brown Bast. An investigation into Its Causes and Methods of Treatment, 7/6 net. Rubber Growers Association, Eastcheap, London, E.C.-3.

(14) *Sharples, A.* - A consideration of Recent Work on the Brown Bast Problem. Malayan Agricultural Journal Vol. X, June, 1922, No. 6.

(15) *Sharples, A.* - The Laticiferous System of *Hevea brasiliensis* and its Protective Function. Anns. of Botany, Vol. XXXII, No. CXXVI, April, 1918.

(16) *Sharples, A. and Lambourne, J.* - Preliminary Report on Brown Bast Experiments in Malaya. Malayan Agriculture Journal, Vol. XI, Feb., 1923, No. 2.



HEVEA SELECTION.

EXTRACTS FROM RECENT LECTURES

By

Dr. C. Heusser and Dr. P. J. S. Cramer.

THE following is extracted as printed in the Archief Voor de Rubber Culture—Juli 1924, Dr. Heusser's concluding remarks are as follows :—*

Concluding remarks.—"This concludes the present position of Hevea selection in our experimental station."

"You can see that we have been able with the co-operation of the estates to begin selection work with a liberal supply of starting material and we have approached the problem from different sides; perhaps you got the impression that we have started studying too many problems at the same time. I can well imagine, that at first sight it would seem better to take each question separately and to solve it by large simple experiments with large control plots. With annual crops this would be the correct method, with a perennial tree cultivation like the Hevea tree, *where furthermore the selection work is still at an elementary stage*, we must take other steps. To be able to accomplish something in a life time it is necessary to start with a large number of trees, and the experiments for the explanation of the questions should be accumulated. In this manner it is possible that unnecessary work may be done, yet time is saved. To begin with the experiments should not be too extensive, each large selection experiment takes so much space and is so costly that it must be ensured that the plantation can be worked later on. A failure in a tobacco field can be cleared away in three months; a selection garden of Hevea must however become a tapping field, and at worst it must not become inferior to an ordinary plot. We started in the first place with the aim of working out the problem as quickly as possible by small many sided experiments and have now come to a point where practice can already with advantage make use of the results obtained. We possess mother trees whose bud-grafts will give a much higher yield than the present plantation trees. Further we know that selected seed also will recompense the costs and trouble expended, by giving a higher production, and we have signs which indicate that we will shortly be successful in isolating a high yielding race. *The time has now come for making thorough experiments on a large scale.*"

Interesting results from Bud-grafts are given by Dr. Heusser in the following paras :—

"Up to the present time bud-grafts from 30 different mother trees were tapped. As was to be expected, not all of them proved to be

* Note. Italics mine (A.S.)

good ; the productivity of the sundry clones was very different. We divided them into three groups, according to the results of the first tapping experiments.

I. Clones which are expected to yield more than double the yield obtained from unselected seedlings of the same age. These are A. V. R. O. S. mother trees Nos. 33, 36, 49, 50, 52, 80, 152.

II. Clones which are good but from which for different reasons we await further data until we definitely pass them or not. To these the following numbers belong ; 31, 35, 60, 65, 74, 93, 135, 139, 142, 144, 147, 151, 163, 174.

III. Clones which we have rejected and which were eliminated. Of a few only, a small number of trees are being retained for scientific purposes. Those rejected were Nos. 8, 9, 23, 51, 71, 149, 150, 82.

To confirm the results of the first tapping experiments and to ascertain the increase of production, the clones of the first group and also, part of the second group were tapped regularly every alternate month since the beginning of this year. The results will be published in detail in due time. I want to demonstrate to you some of the latest results. Clone 50, seven trees, 5 years old, gave an average of 16.83 grams per tree per day in January (16-30 Jan.)

I have the last monthly tapping results here (February) from our very best developed bud-graft, No. 16 of Clone No. 80. The yield for 20 days is an average of 24.4 grams per day ; you can see what respectable little sheets they are.

Clone No. 33 (10 bud-grafts) gave an average of 12.4 grams in January. If we make a comparison between the yield of bud-grafts from No. 33 with the December yield of the illegitimate seedlings from No. 133 then this is by far in favour of the bud-grafts, in spite of the fact that they are a year younger."

The following are extracts from a lecture by Dr. Cramer.

The danger of mistakes.—"It is evident that during the planting mistakes have been made, and probably during the budding also. It is not my purpose to pass over this case ; for by paying some more attention to it one can learn a useful lesson from it. He who has layed out pure plantings will know how easily such mistakes are made and how difficult it is to prevent them. The conclusion I will draw from it is in the main : *for a practical planter it is generally very difficult to lay out pure plantings from different numbers.* We cannot take enough precautions to prevent mistakes ; by marking with bamboo sticks ; by budding of each number on its own seedling bed, planting the different numbers on successive days and such measures we can work in that direction. And the second conclusion is as follows : Arrange everything so that later a careful botanical investigation can be carried on and if necessary the figures again can be classified. This will be possible by measuring the yield per lowest unit *e.g.* per tree. So we could correct

all figures, which in our tables were worked out in averages and after the trees primarily had been identified, calculate them again and classify them in the right way."

"I will call your attention to one other source of mistakes. It occurs that the scion dies immediately after the planting and the stock grows a sucker, which, when the plant is not examined carefully may easily be supposed to be a growing budding, even on already older plants on which the sucker with its smoother and different coloured bark at first may contrast with the stem of the stump. Expecially with the scions planted between green manures, which hide the lower part and make difficult the exact examination of the trees, there is a danger for such impurities. Therefore I should advise everybody: examine your planting of buddings, plant after plant and look out for suckers of stumps. Especially in the experiment garden in the Lampongs we several times were able to discover these impurities."

Finishing discussion.—"We have reviewed here the most important data obtained by studying our Heveas in the first year of tapping. As much as possible I have kept to the facts, leaving out discussion of the advantages and disadvantages which buddings may have over seedlings. I have tried to publish sufficient details for the planter to enable him to consider these advantages and disadvantages himself. Our material is not abundant, *we have only an experience covering onè year*, so it seems to be possible that when there will be more data available we will have to revise our opinion on some points. This seems to me less prejudical than to leave different points undiscussed which even can make us better acquainted with the development of budded trees."

"*The best thing to do by far, is to start this work on a small scale* and to plant a field of buddings even when it is only possible on a small scale . . . . . Another thing to call your attention to is, that some of the trees in the 'Cultuurtuin' deserve very much to be used for experiments with buddings, especially because we already know that their buddings give very satisfactory yields. Some time ago I brought together in the Experiment Garden in the Lampong's a good number -some times of buddings, from high yielding Heveas in West, Central and East Java. Only a very few of them appeared to be superior as budding. A typical warning example shows tree Bg. which in the plantation was known as a very high yielder. The tree stood absolutely isolated; undoubtedly this favourable condition has had a great influence upon the yield. Afterwards the buddings do not appear to be peculiarly high yielding at all. *It is not at all sure that all numbers—if we make buddings from our best yielders-will give high yields.* If one wishes to do something in this field and to look out for high budding numbers, then first of all descendants from each mother tree must be kept together and separated from those of the other trees. Only in this way a good idea about the quality of the mother tree for the growing of high yielding buddings can be formed."

"To judge whether a number is fit for budding mothertree we must not only direct our attention to the yield of it. Other characters

too must be taken into consideration. Besides a high yield a fast growth and also a conical stem are generally desired, both in connection with an early production; another desirable character is resistance against brown bast disease. . . . . ."

"Until now I have kept to figures and facts. We used them as data for comparing the advantages and disadvantages of buddings against seedlings and we tried to call your attention to a second point:—the greater uniformity of buddings certainly a marked advantage for the plantation work. But the budding process contains still many more possibilities.

"In the 'Cultuurtuin'; we already succeed in budding on each other very different species of Hevea. We also know that scion and stock have an influence upon each other while they may differ in many respects. The possibility of bringing together by budding, parts of trees belonging to different species enables us to build up Hevea trees of which root and stem have characters which meet special requirements, especially as to the soil."

"Many hereditary characters slumber in the cells of the wild Heveas in the virgin forests of the Amazon basin. These characters can be put in service for our general purpose:—to decrease as much as possible the sacrifices of labour and capital necessary for getting a ton of rubber. Once I had the opportunity myself to make a grab in that treasure chamber of nature. I got several new varieties of *Hevea brasiliensis* and some other species of Hevea. They begin now to fruit so they can be used for further multiplication. We are now starting further budding experiments with them.

"*Meanwhile all this is only in the beginning.*—When our work will be somewhat further I hope to meet you in the 'Cultuurtuin' again to discuss the results."

In several articles relating to Bud-grafting and allied work, other workers have referred to the critical attitude of the writer and his colleagues towards this question. Our criticisms have never been inspired because of studied opposition, but merely with a desire to maintain the correct scientific attitude and if possible to point eventualities. That our criticisms were valid is obvious from the quotations given above. We have pleaded that great care must be observed if reliance has to be placed on results—a point stressed by Dr. Cramer, in his references to the danger of mistakes; that the work was still in the experimental stage, (—a necessary and invaluable experiment but —an experiment,)—a point stressed by Dr. Heusser in his "The time has now come for making thorough experiments on a large scale, and by Dr. Cramer—"Meanwhile all this is only in the beginning." The disease aspect is obvious to all scientific workers, and with reference to Brown Bast both Dr. Heusser and Dr. Cramer evidently realise it as a factor of importance; the wider aspect of probable new diseases should not be forgotton however. It was pointed out early in 1923 by one of the officers of this Department (W.N.C.B.) that if any success is obtained, it will only be from a limited number of mother trees which bud true as regards yield and advice was given to Malayan

estates contemplating budding to lay down test plots of say 1 acre each. Dr. Cramer gives similar advice. The value of this advice is reflected in Dr. Heusser's results; out of 29 mentioned he could select 7 clones only which definitely could be said to have all the necessary advantages. Our attitude can be summed up in the words of the Plant Physiologist (Mr. W. N. C. Belgrave) in a lecture given at Malacca in July 1922. "One point is certain, work must be undertaken in Malaya without delay. The only test is that of growth and tapping, a matter of six years at least—this sorting out of mother trees should be undertaken soon, so that should bud-grafting prove successful we may not be left behind."

How far do the results presented in the lectures of Dr. Heusser and Dr. Cramer meet this attitude? Dr. Heusser gives results of only 14 tappings but says the results will be published in full detail in due time. The tappings were started at the beginning of 1924 and the lecture delivered on 3rd March 1924, so that only two months tapping records could be available. There is no wish to make destructive criticism on such a point, but it is patently obvious that longer tapping records are necessary before any sound conclusions can be drawn.

Relating to questions of yield one other point may be made. The general growth conditions will impose a limit upon ultimate yields, so that cultivation in the form of manuring etc. must be undertaken if yields are to be unlimited. At what point will this limit be imposed? Attention may be drawn to the $\frac{3}{4}$ Spiral plot in the preceding article which over a tapping period of 26 months gave an average monthly tree yield of 1.34 lbs. Assuming 100 trees to the acre and tapping daily, a total of 1608 lbs. per acre is realised. If unlimited yields are desired, tapping systems can be devised on present day trees in Malaya which would give astounding yields if the health of the trees were not considered. Thus the vital distinction in bud-grafting work is the question of resistance or non-resistance to disease *i.e.*, will Hevea bud-grafts give higher yields and maintain the disease resisting capacity of present-day trees. As we have pointed out—there is no definite guiding line;—only experiment can give us information, and there are indications that the disease factor may come to be considered of major importance.

A. S.

LONDON MARKET PRICE LIST, 3rd QUARTER 1924

Oil Seeds.

Castor (Bombay)	-	£29.7.6 per ton.
Copra (Ceylon)	-	£31 ,,
Do. (Straits)	-	£29.17.6 ,,
Cotton (Egyptian)	-	£13.2.6 ,,
Do. (Bombay)	-	£11 ,,
Croton	-	27/6—32/6 per cwt.
Desiccated Coconut (fine)	-	40/6 ,,
Do. (medium)	-	40/- ,,
Do. (coarse)	-	44/- ,,
Gingelly (Chinese)	-	£26.7.6 per ton.
Groundnuts (Gambia, undecorticated)	-	£19 ,,
Do. (Chinese, decorticated)	-	£25.5 ,,
Linseed (Bombay)	-	£22.12.6 ,,
Do. (Plate)	-	£20.3.9 ,,
Palm Kernels (West Africa)	-	£20.15 ,,

Oils.

Castor (Madras)	-	74/6 per cwt.
Do. (pharmaceutical)	-	78/- ,,
Do. (1st pressing)	-	73/- ,,
Do. (2nd pressing)	-	71/6 ,,
Coconut (Cochin)	-	58/- ,,
Do. (Ceylon)	-	47/3 ,,
Cotton seed (Egyptian, crude)	-	44/- ,,
Do. (Bombay)	-	41/6 ,,
Groundnut (Oriental, crude)	-	48/- ,,
Do. (English)	-	49/- ,,
Linseed (Calcutta)	-	42/- ,,
Do. (Plate)	-	41/- ,,
Palm (Lagos)	-	£39.10 per ton.
Do. (Sumatra)	-	£36.2.6 ,,
Palm kernel	-	42/- per cwt.

Oil Cakes.

Coconut	-	£10.10 per ton.
Cotton (Egyptian seed)	-	£9.—£9.5 ,,
Do. (Bombay seed)	-	£8.5 ,,
Groundnut (undecorticated)	-	£10.12.6 ,,
Do. (decorticated, 50% oil and albuminoids)	-	£12.15 ,,
Linseed	-	£13.15—£14 ,,
Palm kernel	-	£7.10—£7.12.6 ,,

Essential Oils.

Cajeput	-	3/- per lb.
Camphor (Chinese, crude)	-	2/7 ,,
Do. (Japanese, refined)	-	2/11 ,,

Essential Oils.—*contd.*

Camphor (oil)	-	60/-—65/- per cwt.
Cinnamon (Ceylon, leaf)	-	5½d.—6d. per oz.
Citronella (Ceylon)	-	3/3 per lb.
Do. (Java)	-	5/4 ,,
Clove	-	7/-—7/6 ,,
Lemon grass (Cochin)	-	3/6 ,,
Lime (West Indian, expressed)	-	9/- ,,
Do. (do. distilled)	-	5/3—5/6 ,,
Patchouli (Penang)	-	16/6 ,,
Do. (Mysore)	-	22/6 ,,
Vetiver (Bourbon)	-	50/- ,,

Spices.

Capsicums (East Indian)	-	40/-—45/- per cwt.
Do. (Nyassaland)	-	60/-—65/- ,,
Chillies (Zanzibar)	-	35/-—40/- ,,
Do. (Nyassaland)	-	50/-—60/- ,,
Do. (Japan)	-	149/- ,,
Cinnamon (Ceylon)	-	11d.—1/2 per lb.
Cloves (Zanzibar)	-	1/-—1/1 ,,
Do. (Penang)	-	2/6—3/- ,,
Ginger (Japan)	-	80/-—95/- per cwt.
Do. (Jamaica)	-	140/-—170/- ,,
Mace (Bombay and Penang)	-	2/4—3/- per lb.
Nutmegs (Singapore and Penang)—		
110's	-	2/- ,,
80's	-	2/4 ,,
64's—57's	-	2/5—2/6 ,,
Pepper (Singapore, black)	-	5d. ,,
Do. (do. white)	-	8d. ,,
Turmeric (Bengal)	-	80/- per cwt.

Drugs.

Cinchona Bark	-	According to analysis.
Cocaine (hydrochloride)	-	16/3 per oz.
Ipecacuanha (Matto Grosso)	-	8/3—8/6 per lb.

Natural Dyestuffs and Extracts.

Annatto (seed)	-	1/1—1/2 per lb.
Gambier (block)	-	65/- per cwt.
Do. (cubes)	-	80/-—90/- ,,

Gums and Resins.

Damar (Singapore)	-	30/-—150/- per cwt.
Do. (Batavia)	-	120/-—160/- ,,
Dragon's blood (reeds)	-	£18—£20 ,,
Do. (lump)	-	£11—£28 ,,
Guttapercha (genuine)	-	2/9—6/- per lb.
Do. (Sarawak)	-	3/-—4/- ,,
Do. (Siak, reboiled)	-	10d. ,,
Jelutong	-	£30—£60 per ton.

Fibres.

Cotton (American Ord. to F.G.M.)	-	15.39d.—17.39d. per lb.
Do. (Egyptian Sakellaridis, G.F. to fine)	-	24.50d.—27.35d. ,,
Hemp (Manila, "J" grade)	-	£42 per ton.
Do. (Mauritius)	-	£35—£46 ,,
Do. (New Zealand)	-	£35.10—£37.10 ,,
Do. (Sisal)	-	£21—£42.10 ,,
Kapok (Indian)	-	9d. per lb.
Do. (Java)	-	1/3 ,,

Foodstuffs.

Cocoa (Ceylon, plantation)	-	60/—98/- per cwt (in bond)
Coffee (Malay, plantation)	-	100/—130/- ,, ,,
Do. (Malay, Liberian)	-	78/—83/- ,, ,,
Sago (pearl)	-	25/—28/- ,,
Do. (flour)	-	17/6—18/6 ,,
Sugar (Java, white)	-	20/5 per cwt (excluding duty)
Tapioca (Penang, flake)	-	3¾d.—4d. per lb.
Do. (Penang, flour)	-	18/-—22/- per cwt.

Chemicals.

Acetic acid (glacial)	-	£69 per ton.
Do. (80% comml.)	-	£43 ,,
Acetone (pure)	-	£100 ,,
Ammonia (.880)	-	£22 ,,
Calcium acetate (grey)	-	£19—£20 ,,
Citric acid	-	1/5½—1/6 per lb.
Creosote	-	6d. per gallon.
Formalin (40% vol.)	-	£54 per ton.
Lime Juice (raw)	-	1/9—3/- per gallon.
Do. (concentrated)	-	£21—£22 per basis.*
Sodium bisulphite (60–62%)	-	£18—£19 per ton.
Sodium sulphite (anhydrous)	-	£27.10—£28.10 ,,

---

* Basis = 108 gallons, 64 ounces Citric Acid per gallon.

Received for publication 15*th September*, 1924.